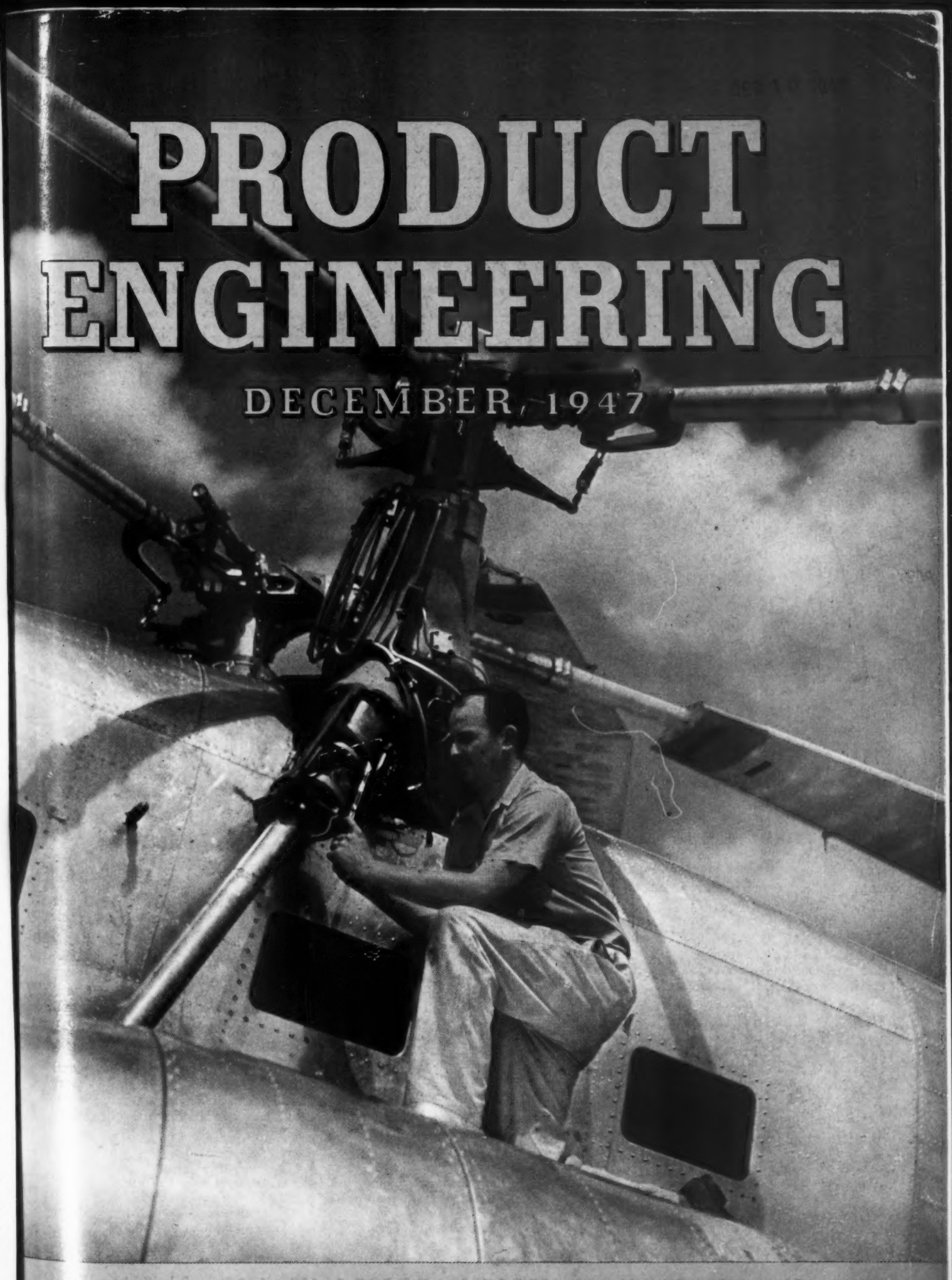
PRODUCT ENGINEERING

DECEMBER, 1947



IN THIS ISSUE—Twin Engined Helicopter + Steel at Low Temperatures + Strength of Bolts + Motor Noise + Accelerating Inertia Loads + Effect of Ribs on Plates

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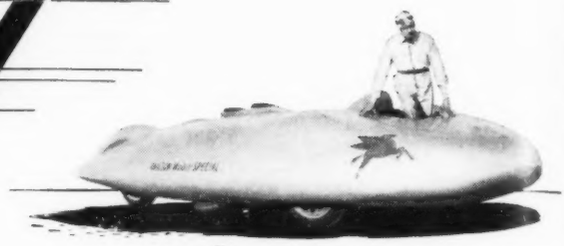
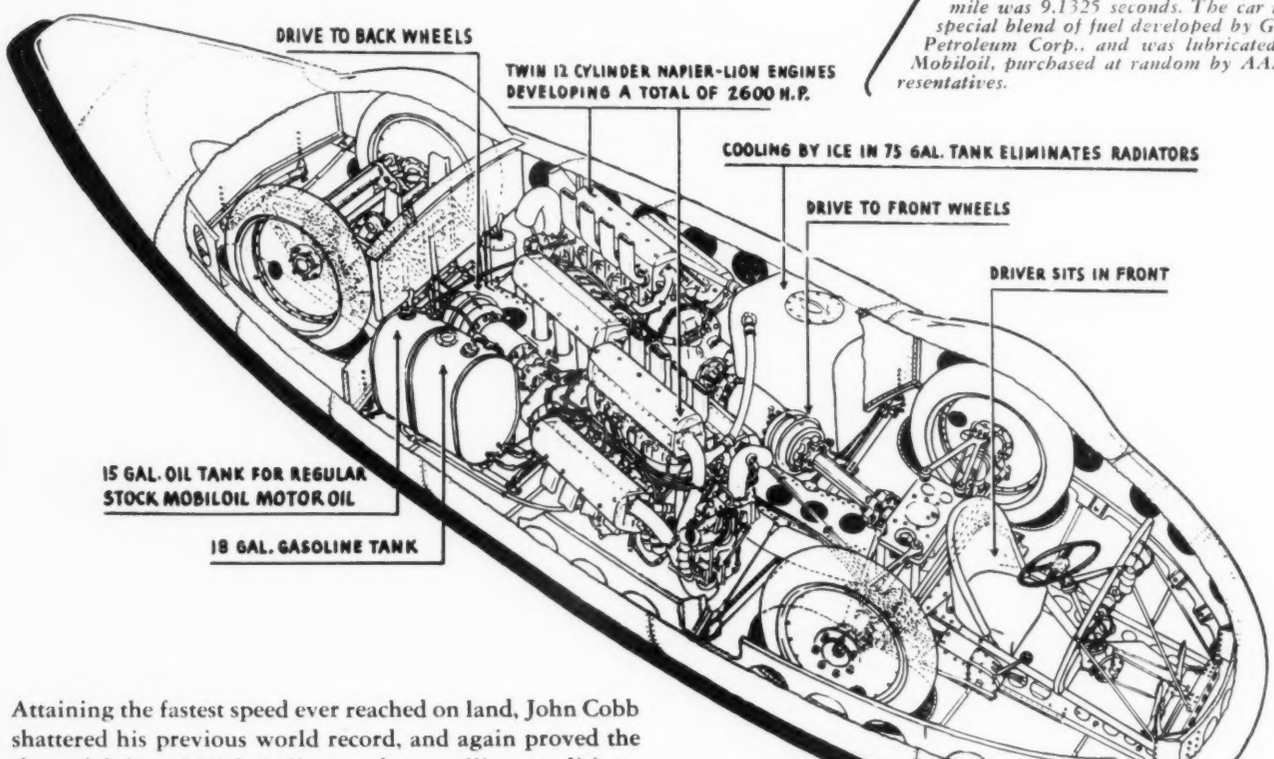
400 MPH

WITH THE HELP OF

NICKEL ALLOYS...



John Cobb drove this "Railton Mobil Special" over the measured mile on the Bonneville Salt Flats in 8.93 seconds . . . a speed exceeding 403 miles per hour. His average time for the mile was 9.1325 seconds. The car used a special blend of fuel developed by General Petroleum Corp., and was lubricated with Mobiloil, purchased at random by AAA representatives.


DRIVE TO BACK WHEELS
TWIN 12 CYLINDER NAPIER-LION ENGINES DEVELOPING A TOTAL OF 2600 H.P.
COOLING BY ICE IN 75 GAL. TANK ELIMINATES RADIATORS
DRIVE TO FRONT WHEELS
DRIVER SITS IN FRONT
15 GAL. OIL TANK FOR REGULAR STOCK MOBILOIL MOTOR OIL
18 GAL. GASOLINE TANK

Attaining the fastest speed ever reached on land, John Cobb shattered his previous world record, and again proved the *dependability* of Nickel alloys under gruelling conditions.

Practically every stressed part in the two Napier "Lion" engines that power his car were made from heat-treated Nickel alloy steels.

ALL PINIONS, GEARS AND SHAFTS in the differential and transmission, supplied by Firth-Derihon Stamping, Ltd., were made from an electric furnace Nickel-chromium casehardening steel, containing 4.3 percent Nickel.

THE UNIQUE UNIVERSAL JOINTS made for this car by Laycock Engineering Co., utilize a 3½ percent Nickel steel spline shaft joined to the housing with bolts of the same Nickel content.

THE SPEEDSTER'S FRAME was produced by John Thompson Motor Pressings, Ltd., in Nickel alloyed steel with a minimum tensile strength of 100,000 p.s.i.

THE STEERING GEAR, from Burman & Sons, utilizes two Nickel steels and one Nickel-chromium-molybdenum steel, heat treated to high strength and toughness.

WHEELS FOR THIS CAR are the same ones made by Dunlop Rim & Wheel Co., Ltd., for Cobb's 1939 record run. They incorporate rims produced from forged rings of a 3½ percent Nickel steel and held together on each wheel by bolts of "18-2" stainless steel, heat treated prior to machining.

Nickel alloys have established notable records in exacting applications. The many compositions available permit selecting the one with extra qualities for a specific use. Discuss your individual metal problems with our technical staff. Write us today.

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IN THIS ISSUE

FRONT COVER

FINAL ADJUSTMENTS on a rotor drive shaft being made on Kellett's twin engine XR-10 helicopter; a full description is given in the Product Designs section on page 88. Kodachrome by Rudy Arnold taken at Kellett Aircraft Corporation's plant North Wales, Pa.

Effects of Low Temperature on Steel

Welded merchant ships built during the war focused attention on the possible causes for their failure. Out of the resulting investigation came much new knowledge concerning the behavior of steels at low temperature. On page 81, H. W. Gillett, chief technical advisor of Battelle Memorial Institute amplifies this explanation and describes what occurs metallurgically when steels are subjected to sub-zero treatment.

Heat Resistant Paints

The need for standards of comparison in the field of heat resistant paints is emphasized by George Black and Howard Sanders in an article on page 85. Requirements that heat resistant paints must meet and the newly developed silicone resin paints are covered.

Hinged, External Friction Shoes

External shoes of the hinged type are discussed on page 134 in another in a series of articles by A. C. Rasmussen, consulting engineer, on the analysis and design of friction blocks and shoes.

Spot Welded Aluminum Components

Results of a wartime test program conducted to determine the effect of repeated loads on the fatigue strength of spot welds in sheet and stringer combinations, are described on page 158, by Robert C. McMaster and Horace M. Grover of the Battelle Memorial Institute. The second of two articles.

Industrial Adhesives—II

An ever widening range of industrial adhesives has led designers to consider this method of construction in many specialized applications. On page 137, Nicholas J. De Lollis, National Bureau of Standards, discusses properties and uses of thermosetting resin adhesives, in part II of a two part series. Applications of all types of adhesives in wood, metal-to-wood, metal-to-metal, metal-to-glass, and plastic and rubber bonding are covered.

Soldered Ceramic-to-Metal Seals

A little known type of gasketless seal is the soldered ceramic-to-metal seal used for cable terminals, bushings, and connectors. On page 154, A. L. Jenny, Works Laboratory, General Electric Company, discusses design considerations of this promising type of seal for making gas-tight joints between ceramics and metals.

Acceleration of Rotating Inertia Loads

Determining the time required by a varying torque to produce a given change in the angular velocity of an inertia load is a frequently recurring procedure in engineering design. James D. Burby, consulting engineer, see page 102, describes three methods by which time-speed characteristics can be calculated for such loads when the torque can be defined or approximated as a function of speed.

Strength of Ribbed Beams

Ribs are added to beams to reduce deflection, and thus increase stiffness; however, this may result in increased bending stresses that will actually weaken the beam. On page 122 A. R. Holowenko, Assistant professor of mechanical engineering, Purdue University, discusses the effect of rib proportions on beam bending strength?

Strength and Clamping Force of Bolts

Can a predicted applied torque be used to obtain a desired clamping force? What is the strength of a bolt under torque of a nut? On page 130, Kenneth H. Lenzen, Research Associate, describes findings based on tests at Northwestern University for the American Institute of Nut, Bolt & Rivet Manufacturers.

Compact Relay Designs

The purpose of relays in aircraft is to save weight. Design factors influencing the efficiency of power and circuit relays for aircraft are discussed by T. B. Holliday, President of Mueller Accessories, Inc., on page 118. Mechanical, electrical and environmental requirements are covered.

Minimizing Motor Noise

Quiet motors are becoming increasingly important for satisfactory performance of many industrial and consumer products. On page 110 William O. Ordinanz, a mechanical engineer of Brasov, Rumania, analyzes the fundamental electrical and mechanical causes of motor noise and suggests remedies.

JANUARY HIGHLIGHTS

Military Research for Peacetime Living, by Harold Schor, Associate Editor. The armed services are spending money for research at a faster rate than they did during the war. Is it all "down the drain"? A factual, detailed study reveals that results of military research are as tangible in civilian life as all other types of research.

High-Temperature Greases, by H. A. McConville of General Electric Company. Discussion of desirable properties of high-temperature greases and how to apply them.

Recording Stress Level Gage, by R. C. Walker, engineer, and J. H. Meier, research engineer, Bucyrus-Erie Company. Strain gage that correlates levels of stress occurring in structural members with phases of operation.

Special Small Motors for Industrial and Commercial Products, by H. M. Fulmer, Bodine Electric Company. Discussion includes operating requirements, performance characteristics and comparison of different types of motors for diversified applications.

PRODUCT ENGINEERING *Editorial*

DECEMBER, 1947

Some Are Merely Bricklayers

A STRANGER IN TOWN happened to be passing a construction job and, gazed with interest at the activity. Like all members of "sidewalk superintendents clubs," he wanted to know more about what was going on.

Approaching one of the workmen, he asked, "What are you doing here?" The artisan answered curtly, "Building forms!" Turning to another man, the stranger again asked the question and received the answer, "I'm the electrician on this job." After several further futile attempts to find out more about the project, the stranger approached an old man who was laying bricks with evident care and precision. In answer to the question, the old man looked at him with an expression of pride and enthusiasm: "Mister," he said, "I'm building a cathedral, a great cathedral to the glory of God!"

In our engineering departments there are many who trace, detail, calculate or do some other essential phase of the design project, and look upon the task as a mere chore. Their principal objective is the quitting signal and the pay check. In a few instances even some of the junior executives of the engineering department partake of the spirit of being mere doers of jobs. Rarely do such clock workers become top engineering executives.

The value of men in the engineering department cannot be measured in terms of square inches of drawings or tracings produced. Nor is the intricacy and volume of calculations the sole gage of the full worth of an engineer.

Society pays for goods and services solely on the basis of the value of those goods and services in terms of satisfying material and spiritual needs. The real work of an engineer is not that of calculating and picturing an automobile, machine tool, farm machine or piece of home equipment. His genuine objective is, or should be, to create a product that will bring to its final owners relief from manual labor, comfort, pride of ownership and spiritual uplift.

The real professional engineer is not a mere artisan, or just a wage earning workman, or a salaried executive. He is in truth a person of vision, fruitful of ideas, and imbued with high ideals to serve his fellow men. He is not the spirit of the carpenter, electrician or bricklayer, but the spirit of the old man building a great cathedral to the glory of God.

G. F. Jordenholt

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Cold Testing Laboratory, Wright Field

Operator setting up notched bar impact testing machine in cold room where test temperatures can be lowered to —100 F.

How Low Temperature Treatments Affect Properties of Steel

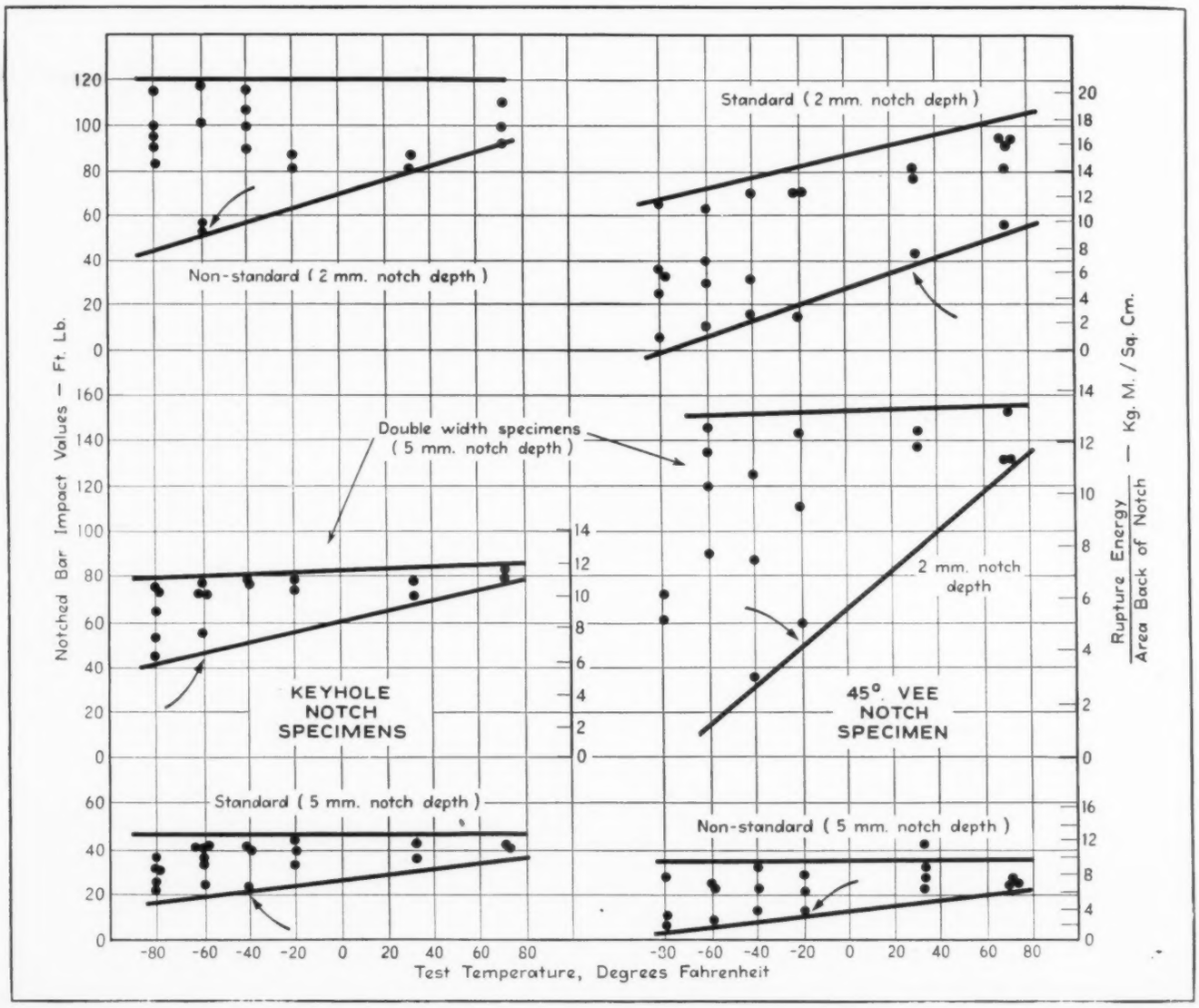
H. W. GILLETT
Chief Technical Adviser, Battelle Memorial Institute

COLD TREATMENT of metals, long used for shrink-fit assembling, has more recently been applied to the control of metallurgical reactions. It is now also coming into greatly wider use for the study of the behavior of metals at low temperatures.

Low temperature for the purpose of inhibiting metallurgical reactions has been widely used to slow the aging of aluminum alloy rivets and there-by keep them in workable condition. The reverse process, the use of low temperature to accelerate or cause continuation of a metallurgical reaction is a recent development. The explanation of it is based on the reactions that occur when steel is cooled from a high temperature.

Austenite, produced at high temperature prior to the quench, must be prevented from transforming to the type of structure met in as-rolled air cooled steel, and preserved down to that temperature level at which martensite starts to form. As the temperature is progressively lowered, transformation of austenite into martensite continues till at some temperature the transformation is complete. The metallurgist denotes the starting temperature by Ms, the finishing temperature by Mf. The martensite range is Ms-Mf. If Mf is at or above room temperature, the usual water or oil quench should complete the transformation.

However, there is a complication in that, in the last analysis, the reaction


Standard (2 mm. notch depth)
Non-standard (2 mm. notch depth)
Double width specimens
(5 mm. notch depth)
2 mm. notch
depth
KEYHOLE
NOTCH
SPECIMENS
45° VEE
NOTCH
SPECIMEN
Standard (5 mm. notch depth)
Non-standard (5 mm. notch depth)
Notched Bar Impact Values — Ft. Lb.
Rupture Energy / Area Back of Notch — Kg. M. / Sq. Cm.
Test Temperature, Degrees Fahrenheit

Low temperature notched bar strengths at various temperatures for a quenched and tempered rolled manganese molybdenum steel, from the War Metallurgy Comm. Report, ASTM, Dec. 1945. Six types of notches were used in bars of 185 Brinell. Arrows indicate appearance of brittle patches in the fracture, and show the lowest energy absorption.

is pressure-sensitive as well as temperature sensitive, and martensite occupies more volume than the austenite from which it formed. Martensite naturally forms first on the more rapidly cooled exterior of the quenched piece. It forms in plates which shoot out, several plates being likely to trap an island of untransformed austenite in their midst. If the temperature drop is slow, as it is in oil quenching as compared to water quenching, there is time for readjustment of the internal stress produced upon the austenite by the earlier formation of martensite. But if the pressure requirement is not met, some of the austenite escapes transformation. Thus oil quenching retains more austenite than water quenching, but water quenching may not be applicable for fear of cracking the object being quenched. Austenite may thus be retained by oil quenching even in steels whose Mf, in water quenching, is above room temperature. If Mf lies below room temperature, no quench merely to room temperature will transform all the austenite.

High carbon content in a steel lowers both Ms and Mf. High alloy content has the same tendency, to different degrees with different alloying elements. With relatively low carbon and moderate amounts of alloy, Mf is so far above room temperature that retention of austenite is unlikely. Austenite retention is likely in high carbon steels and especially likely with high carbon and high alloy content, aggravated by the frequent necessity for oil quenching. Austenite retention is common in the carburized case of carburized steels and in many tool and die steels.

If the retained austenite always remained as such, its presence would seldom be objectionable. But the hard, brittle martensite can seldom be used in its original brittle state; it must be toughened by tempering.

Tempering involves heating above room temperature. In such heating the retained austenite may transform to one of the relatively weak structures produced above Ms, or it may still persist. The steel must cool to room temperature from the tempering heat. In such cooling, the austenite still remaining may transform to martensite, as did the bulk of the austenite on the original quench. This second batch of martensite is, of course, hard and brittle, and if not subjected to a

second tempering operation, the steel, now at room temperature, has more or less of this brittle constituent, which is usually detrimental. Tempering, cooling, retempering and again cooling to room temperature may be necessary, since the retained austenite is more reluctant to transform to martensite on the second and subsequent coolings than in the original quench, because it easily becomes stabilized. If it has broken down to the products that form above Ms, or to the so-called bainite product that can appear on long holding between Ms and Mf, the steel has patches in it that have a poorer combination of mechanical properties than has tempered martensite.

It is a straightforward process to continue cooling below room-temperature, down past Mf, by some method of refrigeration, so that only one tempering is required. When extremely precise results are to be obtained, the production of all-martensite by cooling, and then tempering once, gives more assurance of uniformity than repeated tempering, in which products other than martensite can be produced.

It is often difficult to trace any perceptible difference in behavior between structures obtained by repeated tempering and those obtained by making the austenite transform wholly to martensite by a cooling cycle in which cooling is nearly continuous from Ms to Mf. Authorities differ sharply as to whether any real difference in performance exists in high speed steel, a product to which sub-normal cooling is often applied.

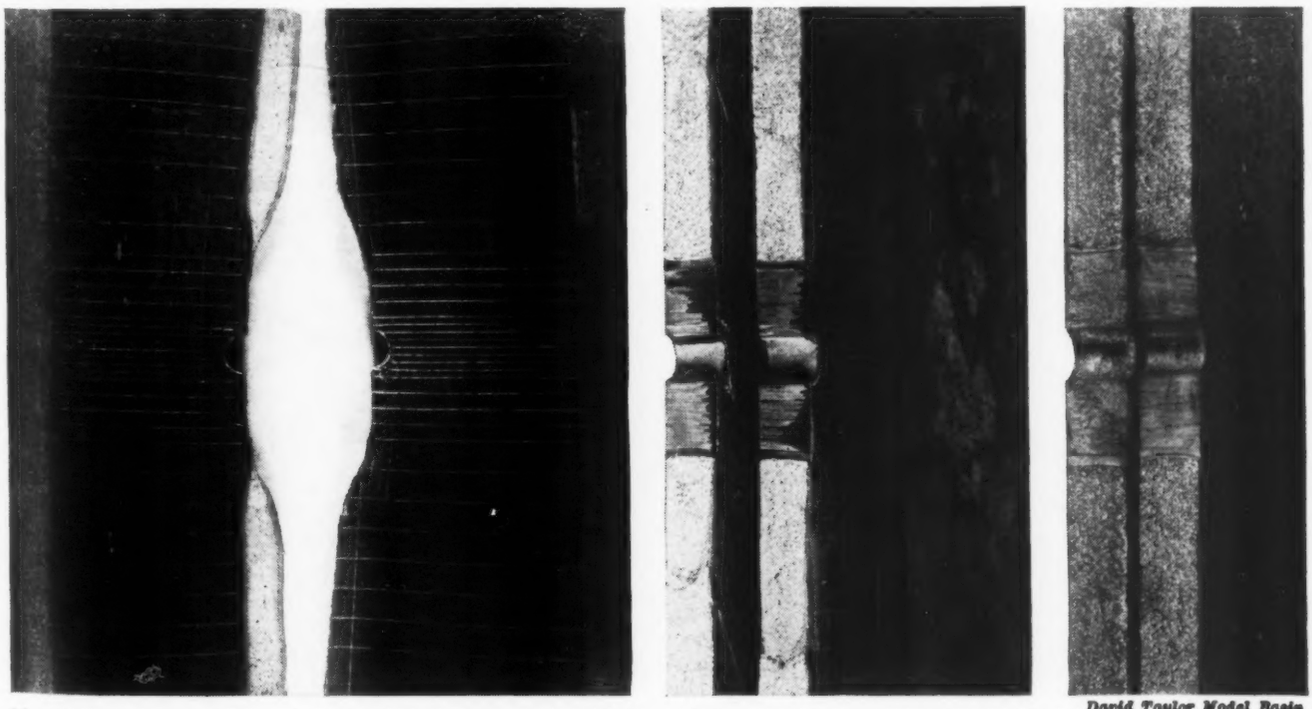
One important requirement of the cooling process from Ms down through Mf is that it should be as nearly continuous as possible. The quenched steel should not lie around at room temperature between the quench and the sub-cooling, for during that time the austenite might stabilize and thereby not respond properly to sub-cooling.

The temperature of the refrigerated enclosure or refrigerating medium to which the quenched steel is transferred for further cooling has to be chosen to suit the Mf of the particular steel dealt with.

Sub-cooling of quenched steel to make the retained austenite transform to martensite is relatively new in commercial practice, but rests on sound metallurgical grounds The process is advantageous for steels that normally retain austenite and which are to go into service where the danger or possibility of retained austenite transforming to an unwanted product would be detrimental.

A further use for cooling of metals is to enable the application of tests at the lowest temperature they will have to endure in service. Northern winter temperatures of — 40 deg. F. are often taken as the criterion and the tests are made at that temperature. High-flying modern planes may have to withstand — 75 deg. F. Some equipment in the synthetic rubber, petroleum and other chemical industries has to operate at even lower temperatures such as that of liquid air or even down to that of liquid helium.

Our most versatile metals of construction, carbon steel and relatively low alloy steel, become less tough at sub-normal temperatures. Ordinary ship plate may have this tendency even at room temperature, as was shown by many failures of welded ships of wartime manufacture. The ship plate was tough by ordinary tensile tests, even at low temperature, but if a concentrated stress was applied and the rigidity of and restraint upon the structure were sufficient, the plate cracked in brittle fashion, fracture progressing at a high speed of the order of a mile a second. Welding the plates into a unit structure provided enough rigidity and restraint to throw



David Taylor Model Basin

Identical test specimens of rimmed, medium steel pulled at different temperatures. Left: 120 F; failed in shear mode with 0.51 in. elongation in 24 inches. Center: 78 F; fractured in cleavage mode, rupture perpendicular to plate plane, with 0.25 in. elongation. Right: 38 F; failed in cleavage mode, no apparent ductility, with 0.08 in. elongation.

the structure over the border line between toughness and brittleness.

The propensity toward brittle behavior is shown when conditions of stress concentration and restraint upon deformation are imposed. Lowering the temperature makes such steel more sensitive to restraint. Local stress concentration created by a notch may start a crack. If the metal is not severely restrained some of it will be displaced, the edges of the crack being thinned down and an equivalent volume of metal being pushed aside by plastic flow. Lowering the temperature, causes the metal to require more pressure to flow plastically. If in addition to this the geometry of the structure is such that there is no free space for the metal to be pushed into, the crack propagates in brittle, shattering fashion, rather than in ductile, tearing fashion.

If specimens are notched and each one broken at a successively lower temperature, a temperature can be found, the "transition temperature," at which the face of the fracture includes metal that has been pushed out toward the outer surfaces where there is space to push it into. This outer metal will have a fibrous fracture. At the center of the fracture there will be a flat, shiny spot where "cleavage" instead of deformation has accured, because that metal was unable to yield to the pressure, since it was hemmed in by surrounding metal and was too cold and stiff to flow against that restraint. At still lower temperatures the brittle spot is larger; finally the whole fracture is brittle.

This behavior depends on the stress concentration, on the restraint, which depends on the dimensions of the piece, and on the way the steel resists deformation under these circumstances. The last, the response of the steel itself, is indicated by a series of notched bar tests over a range of low temperatures. Such a series, applied to different lots of steel, places them qualitatively in order of sensitivity, and is capable of giving the metallurgist useful hints as to how to mitigate the sensitivity. By such tests, it is known that different ways of "finishing" a heat of steel result in different grain size and have large effects on the important metallographic structure. As to the latter, the quenched and tempered structure is far more resistant than the as-rolled structure. Many objects are not suitable for quenching and tempering, so this cannot always be applied. Austenitic steels, such as austenitic stainless, can withstand extreme restraint, but are expensive.

The "finishing" of the steel is not yet under precise enough control to insure that successive heats will have the same behavior, so, when the behavior needs to be evaluated, each heat has to be tested. This is leading to extensive use of notched-bar testing at low temperatures.

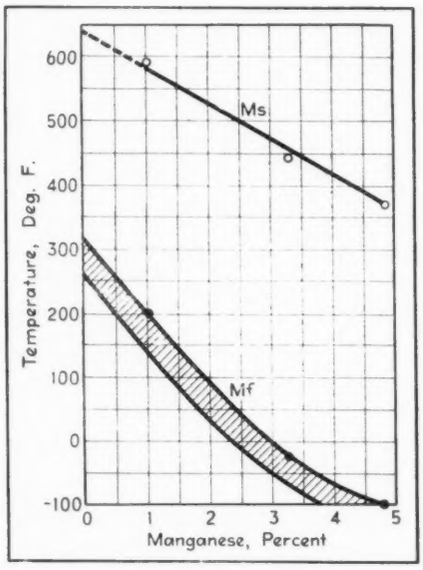
Testing of conventional notched bars serves a useful purpose in guiding the metallurgist, but does not at all serve the purpose of the designer, though there is an all-too-prevalent idea that it does. Because the energy absorbed in the notched bar test tends to decrease at the "transition temperature," the first impulse is to set up a specification that a standard specimen shall show so many foot pounds at such and such a temperature. The tiny conventional notched bar specimen, too small to exercise much mechanical restraint, does not reproduce the conditions of service and its result may give the designer a feeling of security that is entirely false.

The only way the designer can be sure how his actual structure will respond to the service conditions of stress concentration and restraint, is to take the most severely stressed part of his structure, in full size, with its actual notch or other stress-concentrating condition, made from the lot of steel he plans to use, and test that. To insure that he has some leeway, and is not just on the verge of transition, he will carry the tests well below the lowest operating temperature to be met. Very disastrous failures have occurred when reliance was placed on steel meeting the foot-pound specification in the conventional tiny notched bar, when the structure itself had far more restraint against deformation.

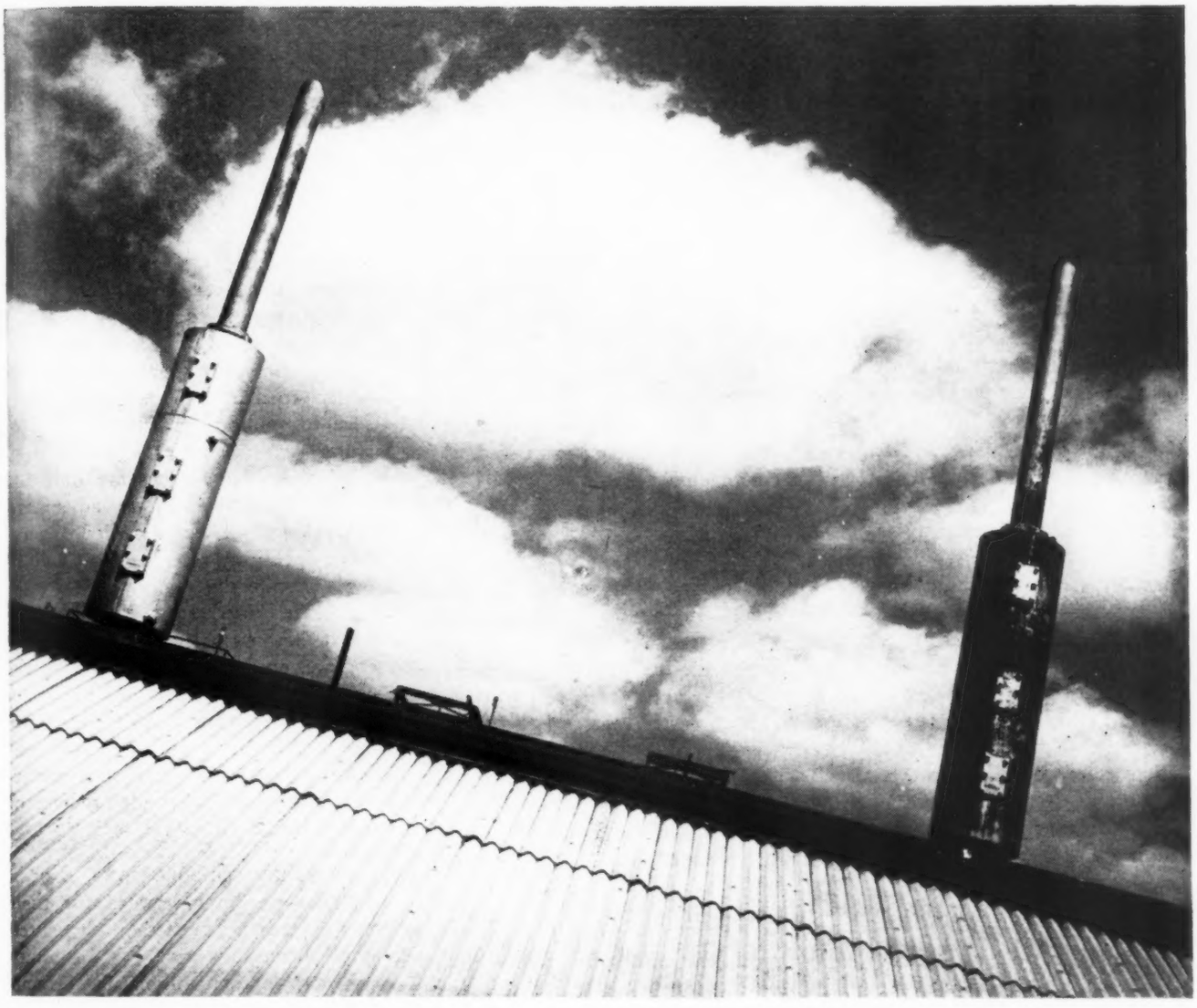
Another factor, too often neglected, is the stress produced by differential thermal expansion, hard to figure in complex structures, and best determined by strain gage measurements on the critical parts of actual structures, under operating temperature conditions.

Thus there is great need for facilities for low temperature testing and examination of full size large parts. Such testing is only in its infancy and the testing engineers have had to exercize much ingenuity in providing the necessary cooling for each particular test. This will still be necessary for the extremely low temperatures such as those of liquid oxygen and liquid helium. The majority of cases, however, on which the designer needs more trustworthy evidence than conventional test specimens will give, can be met by cold rooms such as are in use by automobile makers and high-altitude airplane builders for studying low temperature performance.

There is intense need for reliable engineering information on low temperature behavior of inexpensive steels, made to meet the specific requirements of low-temperature service. Without such information the designer will either risk a disastrous failure, or waste money by employing expensive austenitic steels in order to play safe. He needs to know exactly what his particular design demands, and what sort of steel will meet those demands. Small scale "model testing" and conventional notched bar tests will not give reliable information. Exact information is cheaper in the long run than approximations and guesses.



Curve showing effects of manganese on the Ms and Mf of 0.50 percent carbon steel, from Payson and Sarage, Am. Soc. for Metals, Vol. 33, 1944. With more than 2 percent Mn, austenite transformation is not complete even when cooled below room temperature. Most alloy steels, high in carbon and alloying elements, show similar curves.



Two diesel engine mufflers. The one on the left was painted with silicone aluminum paint, the other with conventional aluminum paint. Both mufflers were exposed to a temperature of 510 F and weathering in a corrosive atmosphere.

Analysis of Heat Resistant Paints

GEORGE BLACK and HOWARD SANDERS

Brief review of heat-resistant paints. The requirements for the ideal heat-resistant paint are listed and the need for specification standards is emphasized.

ALTHOUGH any paint that can be exposed to temperatures up to 500 F without appreciable loss in effectiveness may be considered as a heat-resistant paint, the selection of a coating for a definite set of conditions involves more than the exercise of this sole criteria. Other factors, which determine surface needs, are the presence of chemical vapors, sunlight or moisture; the condition of the surface to which the paint is applied, the base material and the action of the base. Many heat-resistant paints have been developed that can be used for certain applications, but no one paint has been found that is eminently satisfactory for all conditions. To date, the best of the heat-resistant paints are those formulated from one or more of the newly developed silicone resins but even these paints are not ideal.

Coupled with the deficiencies of existing heat-resistant paints is the almost complete absence of suitable standards by which the relative merits of heat-resistant paints can be compared. During 1945 and 1946, the Houston Club of the Federation of Paint and Varnish Production Clubs

made a survey and conducted tests to determine the performance of a number of heat-resistant paints. Exhaustive as the tests were, they left a lot to be desired, because they did not establish a convenient designating system that enables the designer to specify, by code, a paint which will meet the surface needs of the part he wishes to protect.

Ideal Heat-Resistant Paint

The ideal heat-resistant paint should meet the following conditions:

1. Cover a base of: (1) any material such as wood, plastic, metal; (2) any surface condition; (3) any degree of flexibility.

2. Retain effectiveness up to 500 F when: (1) temperatures are of long duration; (2) temperatures cycle; (3) temperatures vary between wide limits; (4) temperatures are accompanied by (a) exposure to water or water vapor, (b) exposure to chemical fumes or chemical baths, (c) exposure to weather, (d) exposure to abrasive action caused by dust, grit, etc., (e) exposure to electrolytic corrosion. The effectiveness of a paint under these conditions is measured by the retention of color, gloss, elasticity, continuity of film, surface hardness and adhesion.

In addition to the performance factors governing the selection of a heat-resistant paint, there are practical considerations such as cost of application, cost of the paint and type of equipment required to apply the paint.

Heat-Resistant Paints in Use

There is some confusion when paints are referred to as heat-resistant or fire-retardant. Fire-retardant coatings are made using paints that will not flash or burn at temperatures up to around 1800 F; consequently, these paints are in a class by themselves-entirely separate from heat-resistant paints. Some of the fire-retardant paints are composed of casein or antimony oxide; others include chlorinated hydrocarbons made from rubber or paraffin. When heated sufficiently, the latter paints release chlorine, which smothers the fire before it has a chance to spread.

JAPANS. Heat-resistant paints have undergone a long period of development. One of earliest paints still in use, with the aid of developments in modern paint technology, is baking japan. Originally japan was made up of a mixture of sap from the varnish tree (Rhus vernicifera) and wax. To obtain a good finish several coats were applied; each coat baked separately for ten to twelve hours at 212 F. Modern japans are made with urea-alkyd, melamine-alkyd, or acrylic ester as an ingredient. These paints are applied in two or three coats. The primer coat is usually baked for three-quarters of an hour at 300 F and at 400 F for an additional ten minutes if maximum resistance is desired. After cooling and a light sanding, a single or double coat is sprayed on and baked for about one hour at 250 F. The resulting finish is noted for its enduring gloss, adhesiveness, color, porcelain-like hardness, and resistance to acid attack; features that are especially desirable for the coating of kitchen stoves, light reflectors, etc.

In general, baking finishes are superior to air-dried finishes because they are more resistant to abrasion, chemical attack and weathering. The application of baked finishes is limited to those products that can be handled by baking equipment.

BITUMENS. Straight bituminous materials are unsuitable because of their low melting or softening points; but blown bitumens or oxidized bitumens are recommended for heat-resistant coatings. High melting asphaltics such as gilsonite and raphaelite are satisfactory whether used alone or in combination with drying oils. The chief advantage of bitumens is their low cost.

LONG OIL. Not as old as the japans, but in use for many years, are paints containing carbon black suspended in long oil. These long oil finishes have a high black gloss, are durable and retain their elasticity long after ordinary paints have dried out, checked and cracked. Normal drying time is about twelve hours. The chief disadvantage, aside from the fact that they will not air dry, is that they can be manufactured only as black or grey coatings.

PHENOLICS. Although alcohol solutions of phenolic resins show good resistance to temperatures up to 400 F, the baking phenolic finishes are more important for their durability and resistance to chemical attack. Heat-resistance results principally from the tough film laid down by the polymerized phenolic resin.

PHOSPHATES. A series of newly developed paints contain a quantity of decomposable phosphates. At elevated temperatures, the vehicle burns off, leaving a residual coating of phosphate that offers some protection from corrosion. However, these paints are not water repellent and are limited therefore to applications where water or water vapor is not present. In addition, phosphate finishes are dull and cannot be pigmented to advantage. They are black when applied and become dark gray after prolonged heating. Despite these shortcomings they have been used successfully on exhaust stacks and rings of aircraft engines, on furnace fronts and on the charging bells of furnaces. The phosphate paints were developed and are still used for automobile exhaust manifolds, exhaust pipes and as a protective coating for the under surface of engine hoods.

ETHYL SILICATE SOLUTIONS. Not in common use but suggested for their heat-resistant properties are pigmented ethyl silicate solutions. For maximum adhesion, laminar fillers such as micronized mica, have been used. Other suitable pigments are chemically inert ochre, chromium oxide or iron. For a white paint, the pigment may be titanium oxide and for a black paint, carbon black. Although these coatings are highly resistant to heat and chemical fumes, they are brittle and lack gloss. Moreover they are porous and give little protection to base metals that corrode readily. Corrosion inhibiting pigments such as zinc-tetroxyl chromate have been used to overcome this objection to some extent.

SILICONES. Recent developments with silicone resins and silicone esters have led to some of the best heat-resistant paints yet discovered. Entirely free of yellowing or chalking, and showing exceptional permanence of flexibility and gloss, silicone paints can be furnished in almost any color and applied by any of the conventional methods. Silicone paints, with the addition of aluminum pigments, can withstand

Table I—Drying Characteristics of Silicone Resins* Using Resins DC 801, DC 802, DC 803, DC 804

Baking Time and Temperature	DC 801		DC 802		DC 803		DC 804	
	Character of Film	Pencil Hardness	Character of Film	Pencil Hardness	Character of Film	Pencil Hardness	Character of Film	Pencil Hardness
Air Dry—16 hrs	Slight tack, soft	....	Tacky	....	Tack-free, soft	....	Soft tack-free	....
1 hr at 140 C	Very slight tack, soft	5-B	Tacky	....	Tack-free	B	Tack-free	B
4 hr at 140 C	Tack-free, soft	5-B	Tacky	....	Tack-free	B	Tack-free	F
1 hr at 200 C	Tack-free	B	Very slight tack	....	Tack-free	HB	Tack-free	H
4 hr at 200 C	Tack-free	B	Tack-free	B	Tack-free	HB	Tack-free	3H
16 hr at 200 C	Tack-free	B	Tack-free	H	Tack-free	2H	Tack-free	6H
1 hr at 250 C	Tack-free	B	Tack-free	2B	Tack-free	2H	Tack-free	4H
4 hr at 250 C	Tack-free	B	Tack-free	B	Tack-free	4H	Tack-free	7H+
16 hr at 250 C	Tack-free	2H	Tack-free	6H	Tack-free	7H	Tack-free	7H+

*Pigmented with 60 parts by weight Titanox ALO per 100 Parts resin solids.

temperatures considerably about 500 F without failure.

Silicone resins were used first in insulating varnishes for electric motors. With the addition of glass fibre, asbestos or mica these varnishes are capable of withstanding temperatures from 390 to 590 F for thousands of hours without serious breakdown. As a result of the successful showing of silicones in varnishes, four more silicone resins were developed that are suitable for paints. The baking time and temperature and the surface hardness of these paints are shown in Table I.

Nevertheless, the silicone paints have limitations. The finish must be heat cured. The cure time is relatively long and the finish is inclined to be tacky. To eliminate tackiness and accelerate drying, the use of cobalt, zinc or manganese driers is suggested. The amount of drier usually does not exceed 0.3 percent by weight of the solid resin content of the paint. Silicone paints are expensive in comparison with other paints. However, if long life is a prime factor, the higher cost is justified. Manufacturers of gas and electric ranges, among others, are increasing their use of silicone paints because the paints show remarkable resistance to heat over long periods of time.

The remarkable performance of the silicone paints has led to the establishment of a silicone-aluminum paint as a standard for the comparison of heat-resistant paints. The standard paint is made up of silicone resin DC 801, thinned with xylol and pigmented with ten ounces of aluminum powder per gal of vehicle. This particular formulation was established as a standard because, after forty hours of heating at 1000 F, the finish showed complete film integrity. In order to compare other heat-resistant paints with the standard paint, some fifty other paints were tested. Only three passed the 800 F test. Two of these contained silicone resin DC 801, pigmented with aluminum or with a combination of zinc dust, zinc oxide and graphite. The remaining paint withstood 950 F for forty hours; this paint contained refined linseed and fish oils together with zinc dust, zinc oxide and graphite.

Addition of Metallic Pigments

The addition of metallic pigments to any of the heat-resistant paints increases their effectiveness.

ALUMINUM. Pigmented paints have good heat resistance, hiding power, durability and light reflectivity. The low thermal emissivity, normally about 30 percent, of aluminum pigmented paints make them far superior to carbon black pigmented paints for applications where heat must be conserved as in furnace fronts, steam lines and reaction vessels. The chemical resistance of aluminum pigmented paints is important for applications in chemical plants and oil refineries, particularly for equipment such as sulphur-containing retorts. They also have been used successfully on lined smokestacks, jacketed kettles and similar parts exposed to relatively high temperatures.

ZINC is another metallic pigment that provides protection long after the vehicle has been destroyed. Zinc dust coatings are useful in protecting metal surfaces exposed to high temperatures and weathering conditions. Applied to boilers and coke converters, these paints have rust inhibiting properties superior to aluminum pigmented paints.

Further development work to develop high temperature paints that can be air-dried and produced and used at low cost is needed. Organic resins and inorganic resins will be explored still further to discover new materials for use in paints. The need for the establishment of paint standards is acute. Only by continued testing of products appearing on the market, and comparing with standards of known composition, can any sort of data be established that will have meaning for the designer.

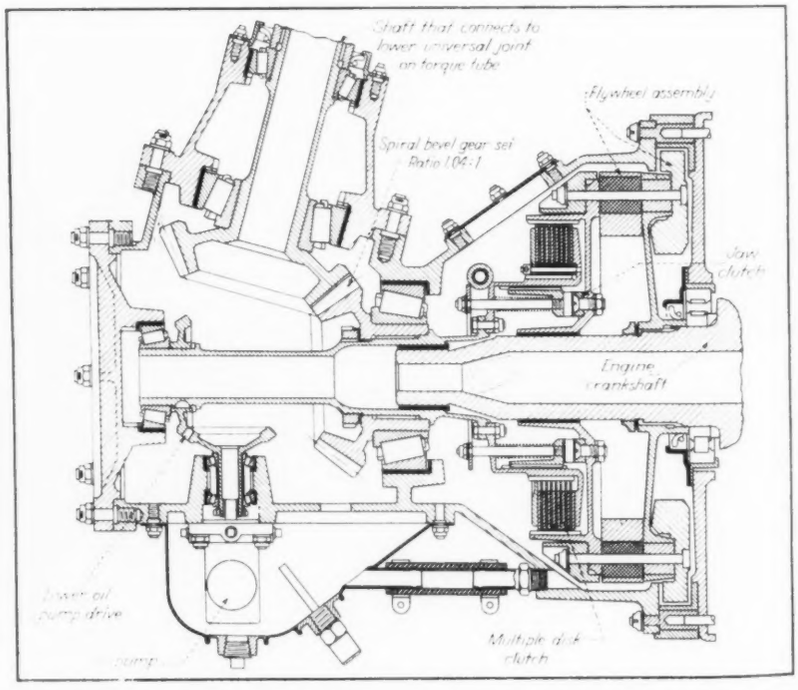
P R O D U C T

Twin Rotors Counteract Torque Reaction

Counter-rotating three-bladed rotors have synchronized engine drives on the XR-10 helicopter manufactured by the Kellett Aircraft Corp., North Wales, Pa. Weighing 11,000 lb, it will hover at 6,000 ft altitude, climb to 18,800 ft or travel forward at 121 mph.

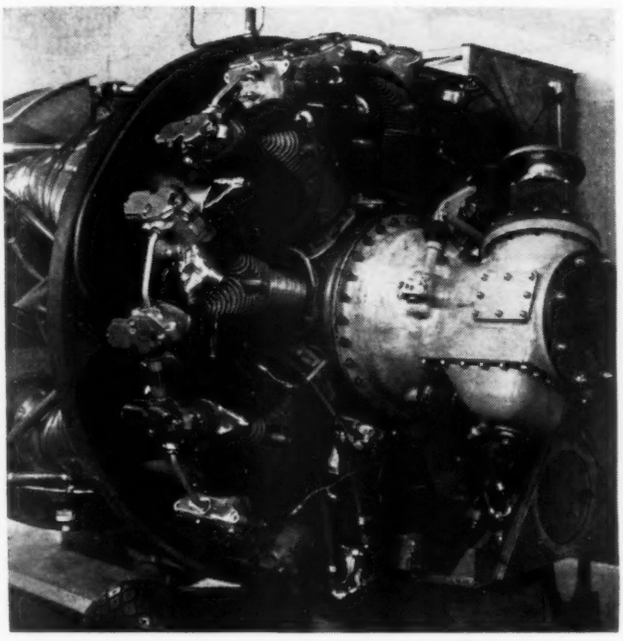
1 **INTERMESHING ROTORS** have 65 ft diameters. Rotor centers are 6 ft apart. Rotor shafts are inclined laterally at an angle of 12½ deg to the vertical center line. Stressed skin construction is used in the fuselage. The tail structure has a horizontal stabilizer and three vertical fins. A movable rudder, which is operated by pedal controls, is mounted on the center fin. Rotor drive shafts are mounted outside of fuselage.

4 **COCKPIT** has seats and controls for both pilot and copilot. Collective pitch stick for vertical flight, is located between the pilots. Throttle controls for both engines are on this stick. Each pilot has a cycle pitch stick for horizontal flight control.

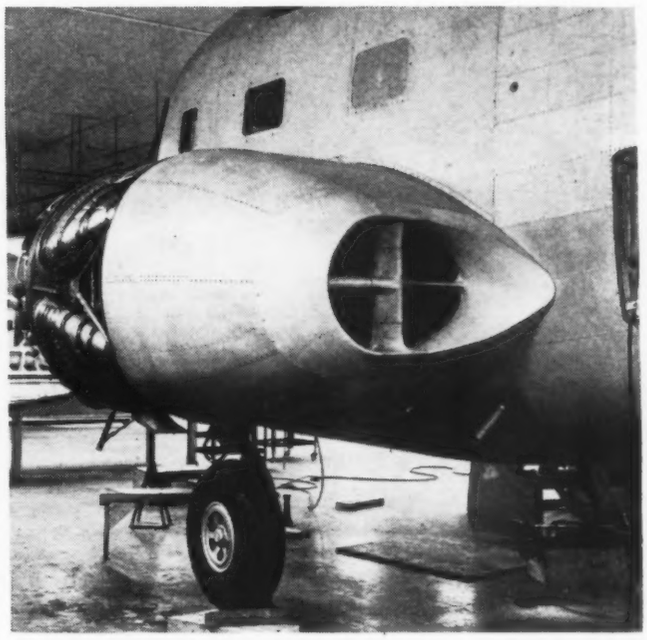

Shaft that connects to lower universal joint on torque tube
Flywheel assembly
Spiral bevel gear set Ratio 1.04:1
Jaw clutch
Engine crankshaft
Lower oil pump drive
Multiple disk clutch

5 **LOWER TRANSMISSIONS** are inclosed in magnesium housings. A wet type multiple disk friction clutch is used to bring rotors up to engine speed so that jaw clutches can be engaged. The jaw clutches assure positive drive connection between rotors and engines. Jaw clutches are designed to override so that one engine will drive both rotors. Combination jet and splash lubrication is provided.

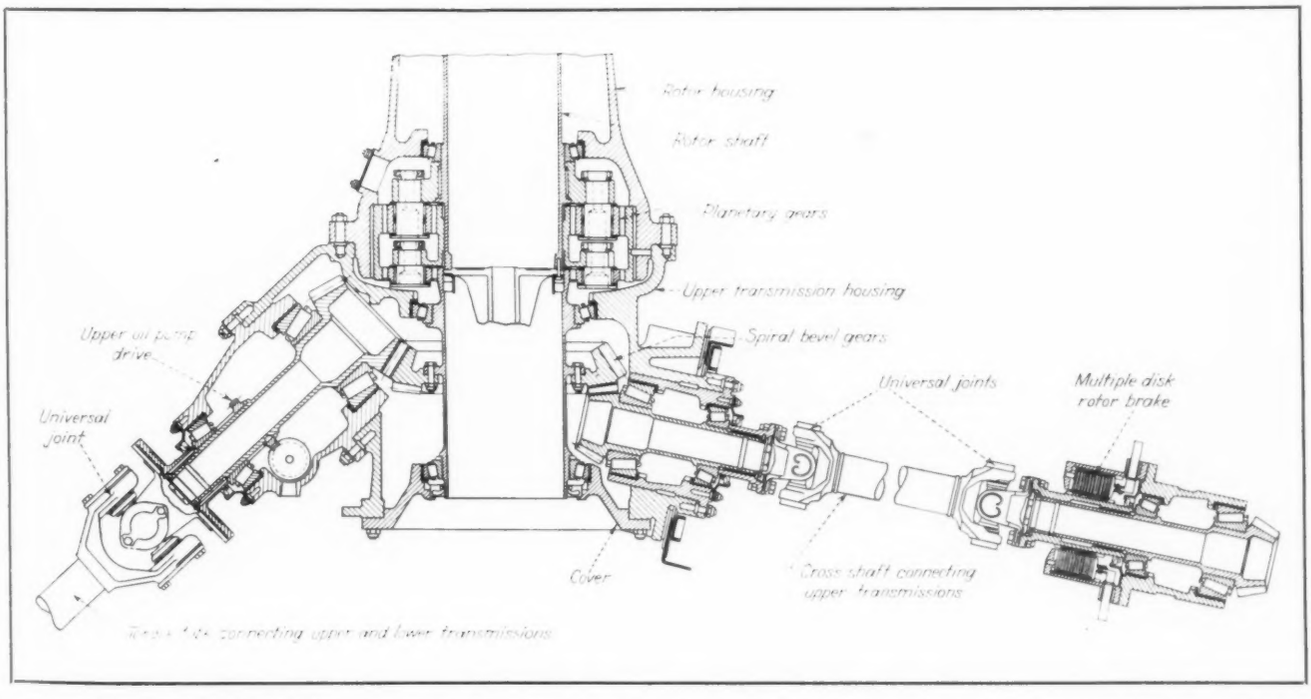
DESIGNS



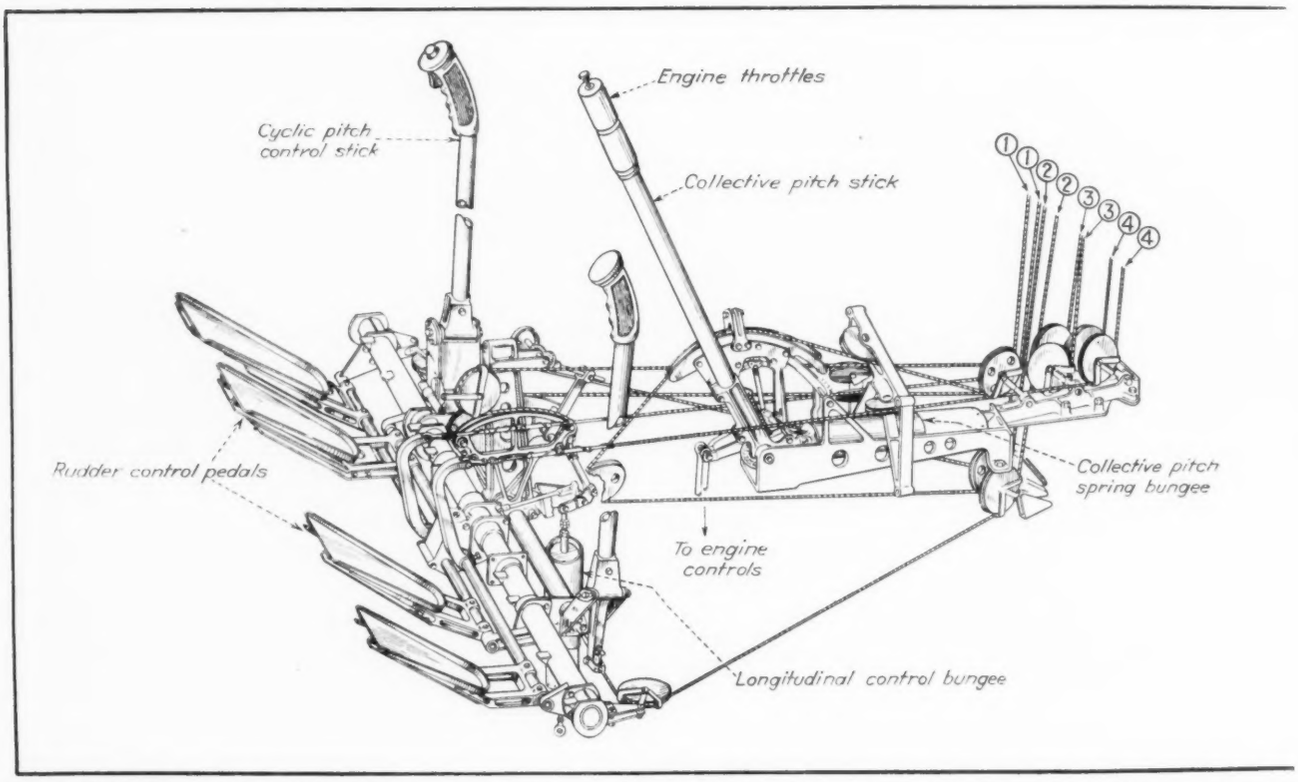
2 **ENGINES** are 9 cylinder 525 hp Continentals, Model R-975-15. They are mounted on each side of the fuselage. Right hand engine is shown. Bolted to the front of the engine is the lower transmission housing assembly. Engine oil cooler is located between the engine and the fuselage. Fuel tank is under floor of fuselage.



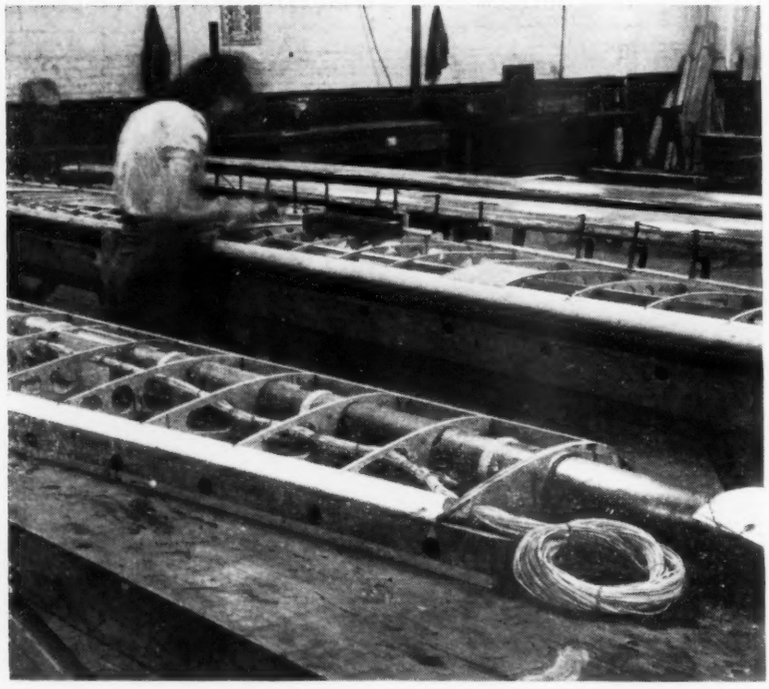
3 **EXHAUST PUMP** system is used for cooling the engines. Exhaust pipes from the engines are placed in stainless steel venturi-shaped ducts. This induced air flow provides engine cooling air when the helicopter is hovering, climbing or in forward flight, without conventional cooling fans, thus saving power.



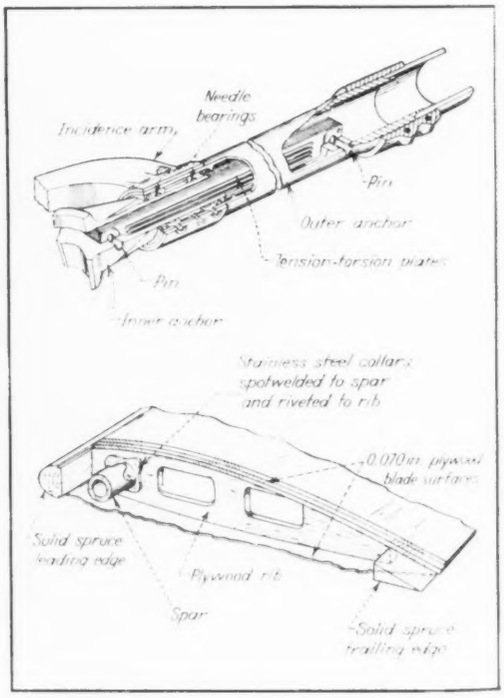
6 **UPPER TRANSMISSIONS** are mounted on the top of the fuselage. The upper and lower transmissions are connected by torque tube drive shafts that have universal joints mounted on each end. Spiral bevel gear set has a 2.26:1 gear ratio. Rotor shafts are timed for mesh of blades by a cross shaft that connects the two upper transmissions. Two universal joints are also mounted on this shaft. A multiple disk brake for slowing the rotors is included in the cross shaft drive. Rotor shaft is driven through an epicyclic gear train that has a 7.43:1 ratio. Rotors revolve at a maximum speed of 140 rpm. Hardened steel shafts are mounted on preloaded bearings.



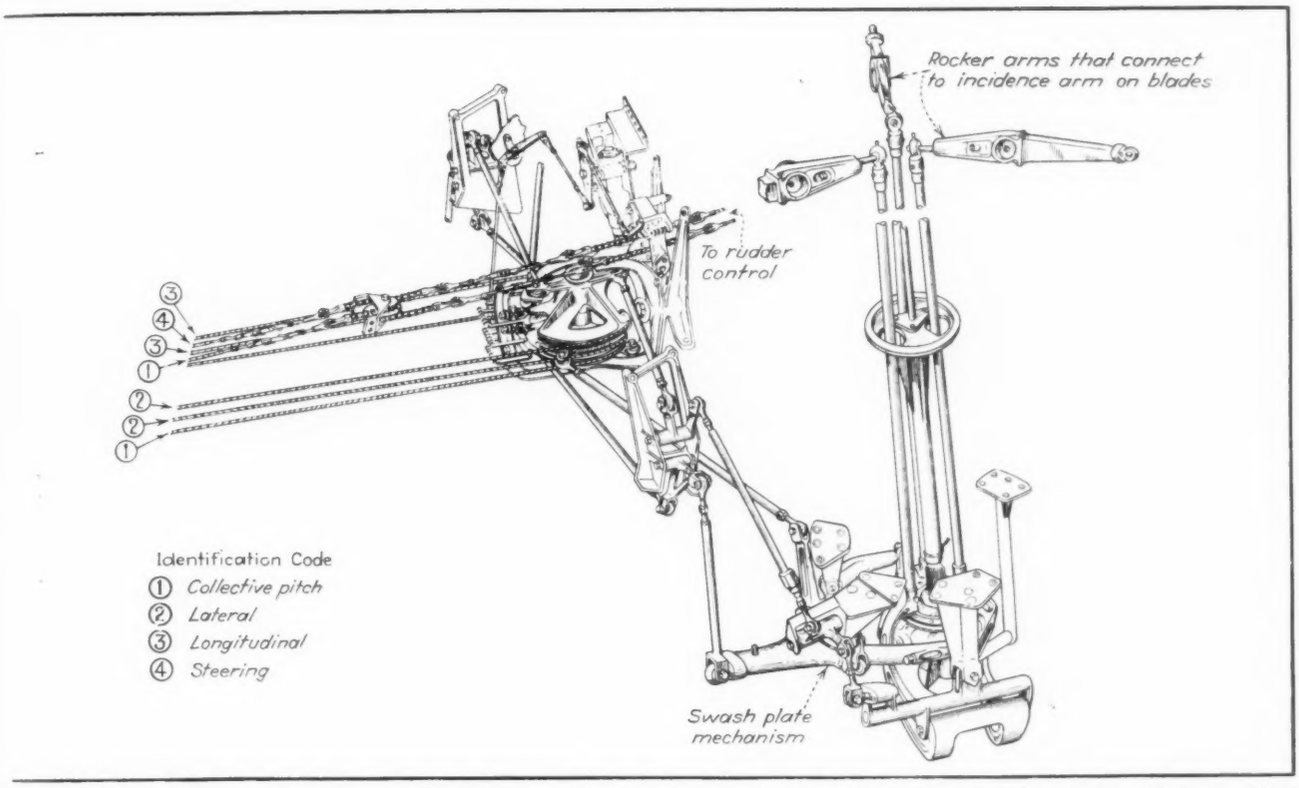
7 STICK AND PEDAL CONTROLS are used to operate the helicopter. Vertical flight is controlled by the collective pitch stick, which changes the pitch of all blades simultaneously. Lateral and longitudinal flight are controlled by the cyclic pitch stick, which changes the pitch during certain phases of blade rotation. Steering of the craft is accomplished by operating the pedals, which act to differentially apply pitch to the rotors and turn the rud-



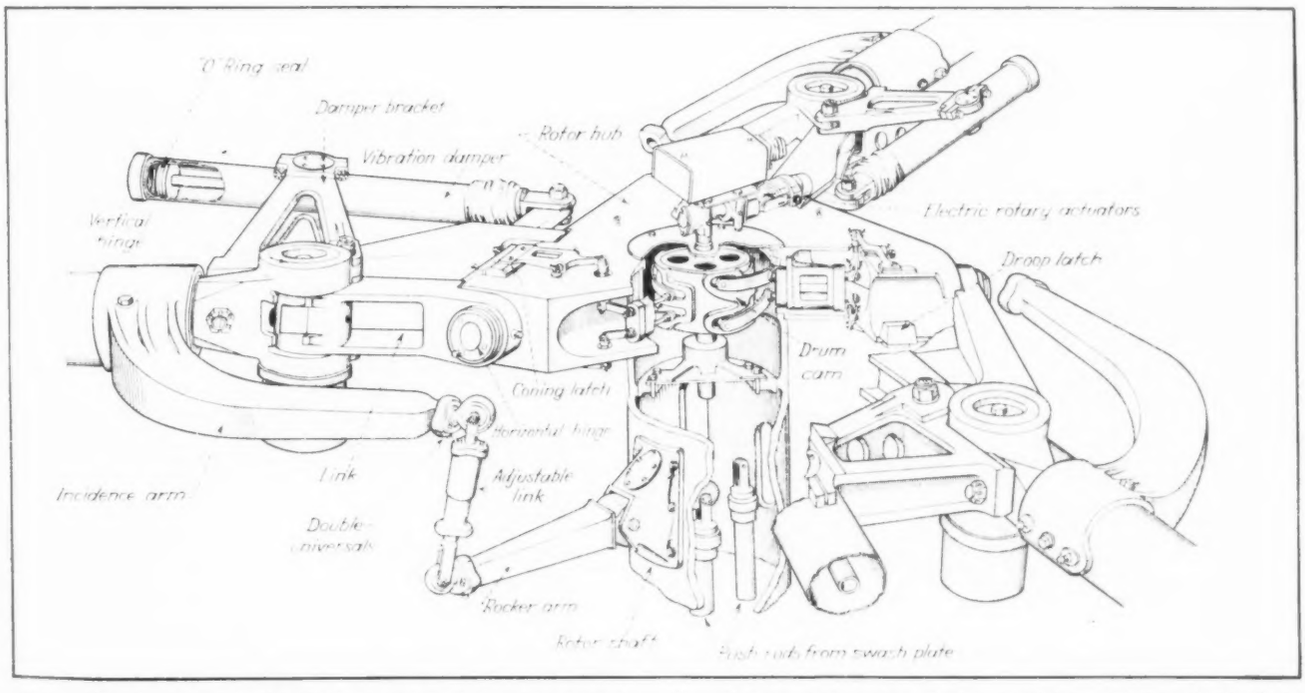
8 BLADES consist of a wood framework built around a chromium-molybdenum tubular steel spar. The spar is step tapered. Blades are balanced, one with the other on a knife edge fixture. Three shot boxes along the blade are provided for spanwise balancing. A weight mounted eccentrically at blade tip is adjusted for chordwise balance.



9 BLADE DETAILS show the tension-torsion plates that replace the usual thrust bearings. Blade pivots around needle bearings. The blade is fastened to the outer anchor with a serrated collar.



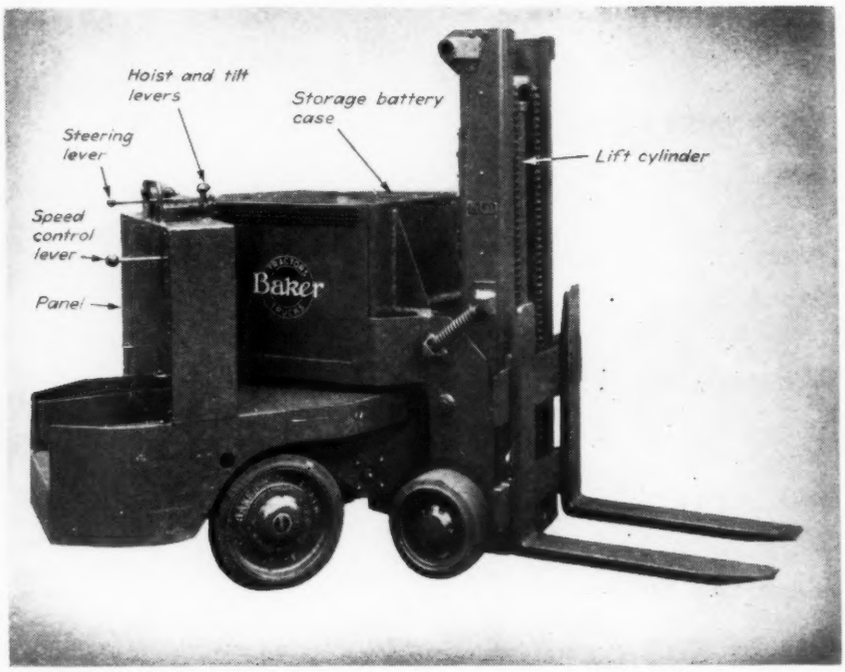
10 **ROTOR HEAD LINKAGE** permits blades to pivot in vertical and horizontal planes, and thus relieve the head and blades from heavy loading. Blade movements in the horizontal plane are damped by vibration dampers that are trunnion mounted on pins at the center of the damper. Centrifugal force and the loading conditions on the blades determine their position. Stops limit these movements. The amount of vertical movement is controlled during stopping and starting by either manually or automatically operated electric rotary actuators in the head. These actuators rotate a drum that causes wedge shaped latches to vary the hinge stops.



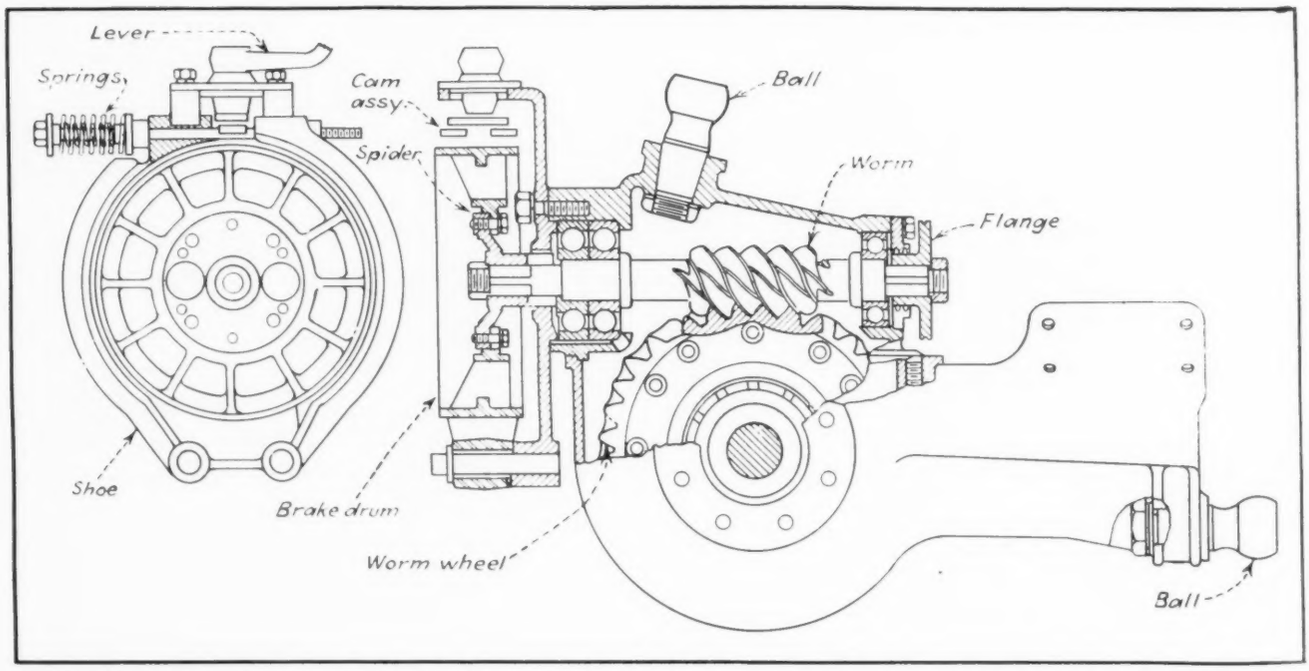
der. Swash plate mechanisms mounted in the top of the fuselage below both rotors are operated by the stick controls to vary the blade pitches as required. The cyclic pitch stick and rudder controls operate the same as a conventional airplane. Only the collective pitch stick is an added control device. Both stick motions have spring bungee devices that aid the pilot in making the stick movements. Turnbuckles permit control cord length adjustment.

Hydraulic Steering for Articulated Fork Truck

By hinging the frame of this electric fork lift truck and using two non-steering axles, it was possible to reduce aisle space in storage warehouses. Manufactured by the Baker Industrial Truck Division of The Baker-Raulang Co., Cleveland; it weighs 9550 lb and has a capacity of 400 lb. It is 54 in. long.

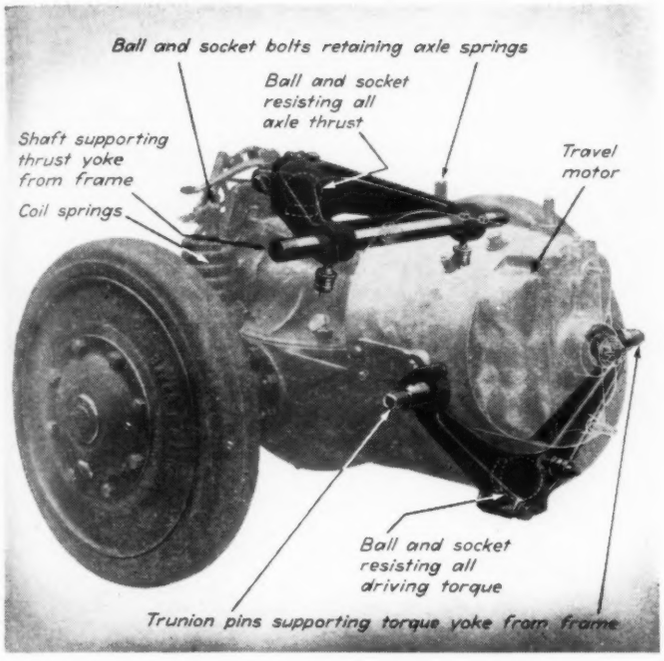


1 ARTICULATED TRUCK has three speeds forward and reverse. Foot pedal control is used to start truck. Releasing the pedal stops the truck. Truck cannot be started unless the controller is in first speed position. Steering is accomplished by moving the steering valve lever to the left or right. The forks can be lifted or tilted by operating lever controls. Frame is a welded and riveted assembly of plates and shaped members. Electric controls, hydraulic units and valves are inclosed in the panel box.

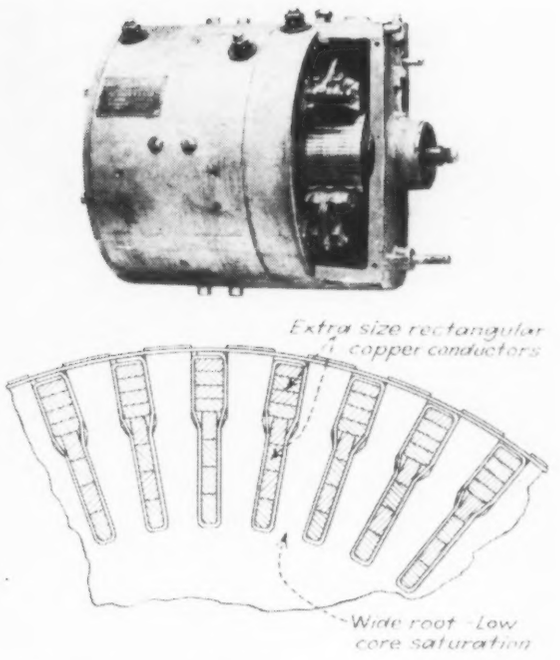


4 WORM DRIVE AXLE is driven by the travel motor through an Oldham coupling. The hardened steel single thread worm is supported by radial and thrust ball bearings. The nickel-bronze worm wheel is bolted to the differential case. Brake for stopping truck is flange mounted on the end of the worm shaft. This brake is the external shoe type. The brake is normally "on" with the springs furnishing the braking force. When the foot pedal is depressed by the operator, the brake is released mechanically and an electrical interlock actuates a contactor in the circuit, which starts the travel motor. If the foot pedal is released, the lever is also released and the springs actuate the brake. Taper mounted ball studs support the torque and thrust yokes.

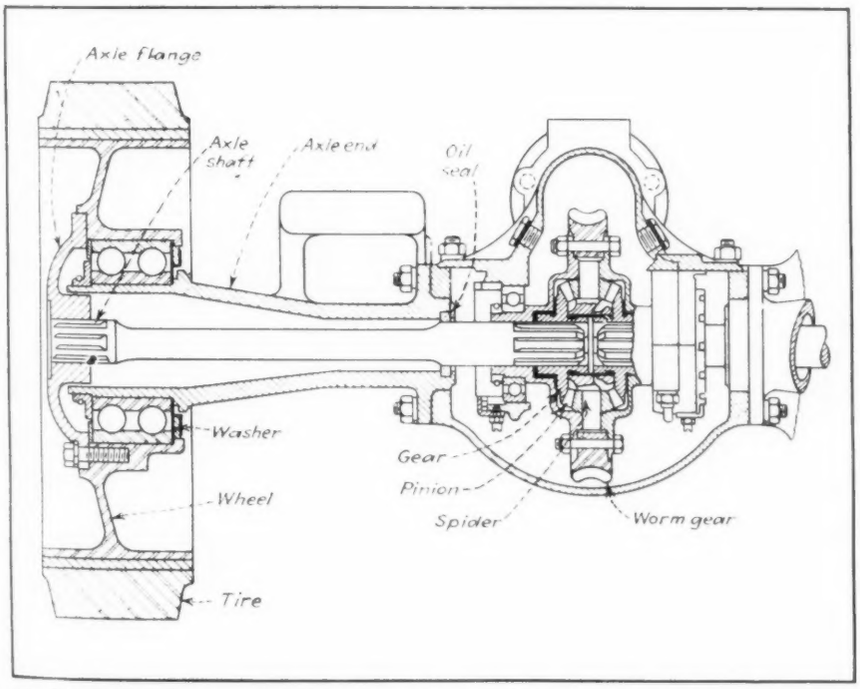
D E S I G N S


Ball and socket bolts retaining axle springs
Ball and socket resisting all axle thrust
Shaft supporting thrust yoke from frame
Coil springs
Travel motor
Ball and socket resisting all driving torque
Trunion pins supporting torque yoke from frame

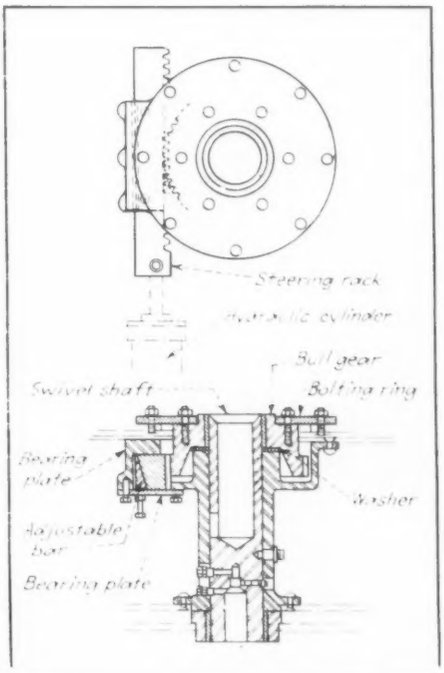
2 SUSPENSION FOR THE POWER AXLE UNIT has both torque and thrust yokes. Known as the Duplex Compensating Suspension it permits the frame sills to remain level while the wheels accept road irregularities. The thrust yoke moves angularly as the springs compress and the torque yoke moves to compensate for the position assumed by the thrust yoke, thus holding axle in truck center plane.



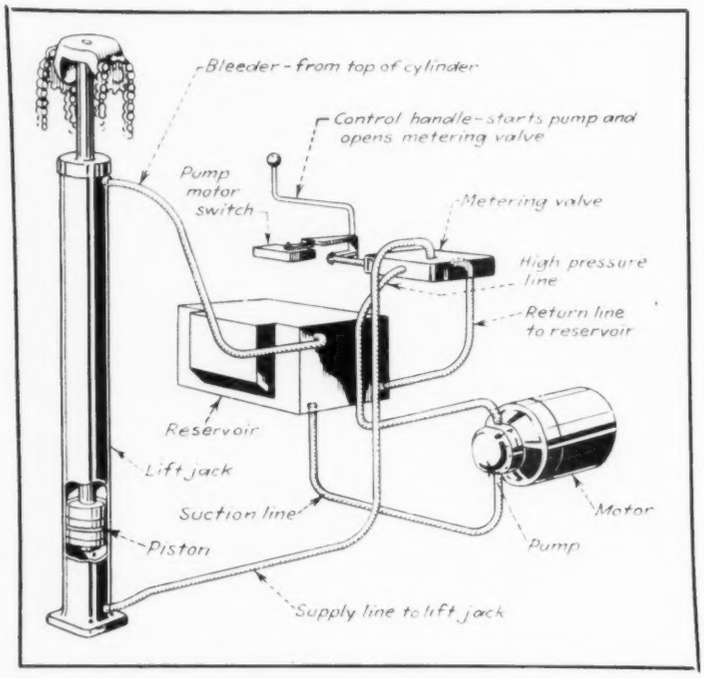
3 D-C TRAVEL MOTOR, which operates from 36 volt battery source, is saddle mounted. Housing consists of a front head upon which the brush holders are mounted, a rear head and a field ring that incloses the poles and coils. Replaceable armature is supported by totally inclosed ball bearings. Electric iron laminations are individually coated to reduce eddy currents.



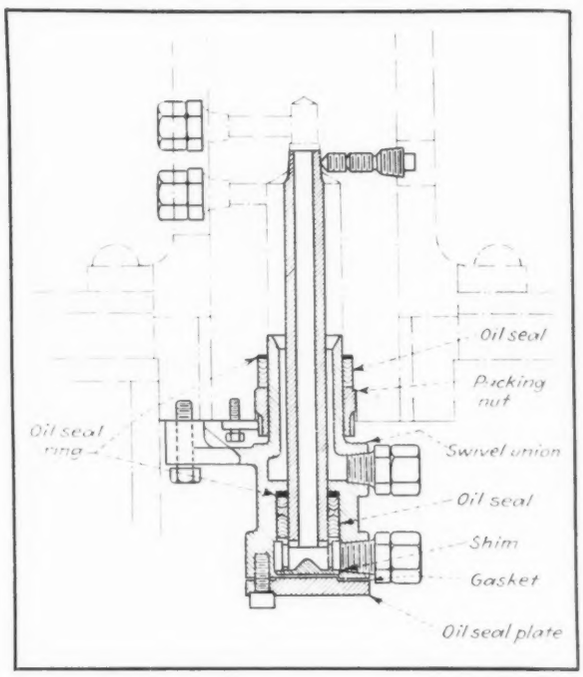
5 DIFFERENTIAL UNIT is mounted on ball bearings. Axle ends are bolted to the side of the housing and carry the double row ball bearings that support the wheel. Axle shafts are splined at both ends. The axle flange is spline mounted on the axle and is bolted to the wheel. Extreme pressure lubricant is used in the worm drive. Differential case consists of two forged members that are bolted together through the worm gear. Axle housing is coated on the inside with shellac to prevent leakage.



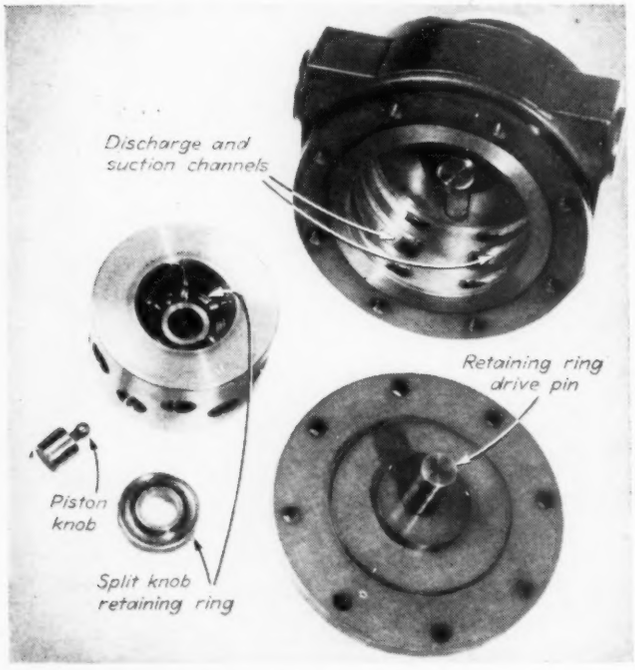
6 STEERING MECHANISM consists of a hydraulic cylinder, rack and bull gear. The truck frame is hinged in the center. The bull gear is mounted on one section and rack assembly on the other. Cylinder is operated by moving the steering control lever.



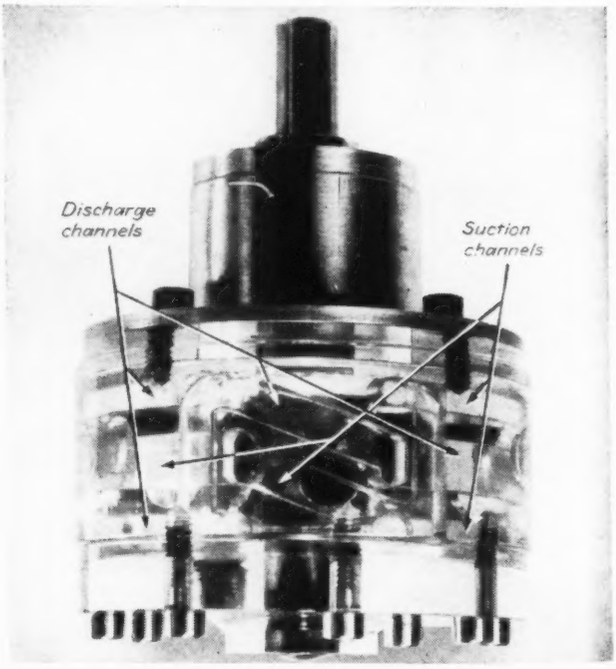
7 HYDRAULIC SYSTEM for lifting the fork consists of a motor, pump, valves and a hydraulic cylinder. The pump does not operate until the operator moves the control lever. A limit switch at the top of the piston travel shuts off the pump and stops fork lift. If the limit switch does not function, and overtravel occurs, a by-pass valve is automatically opened by internal pressure, thus stopping piston.



8 SWIVEL UNION in the swivel shaft of the truck avoids the use of long flexible hose connections between the lift cylinder and pump section. A two-step hole is bored in the bottom of the swivel shaft. The union, which consists of two tubular members that fit into the two bores, is mounted to the frame on the maintruck section.



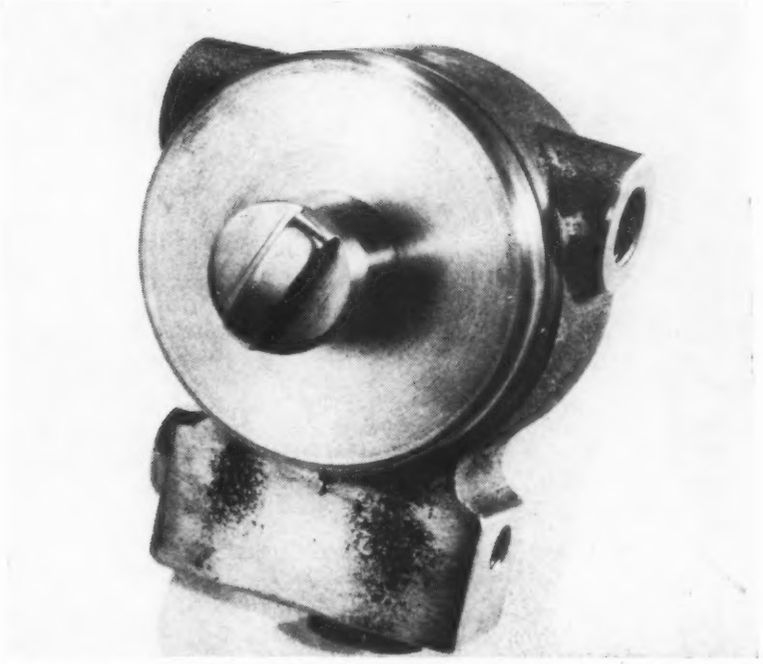
2 KNOBS on the piston rods are held in the groove between mating faces of the split retaining ring. The rotor turns the ring mounted on eccentric shaft. Ring thus imparts reciprocating motion to the pistons. Neither ring groove or piston axis locations are critical. Volumetric adjustment on some models is made by varying eccentricity of the retaining ring drive pin.



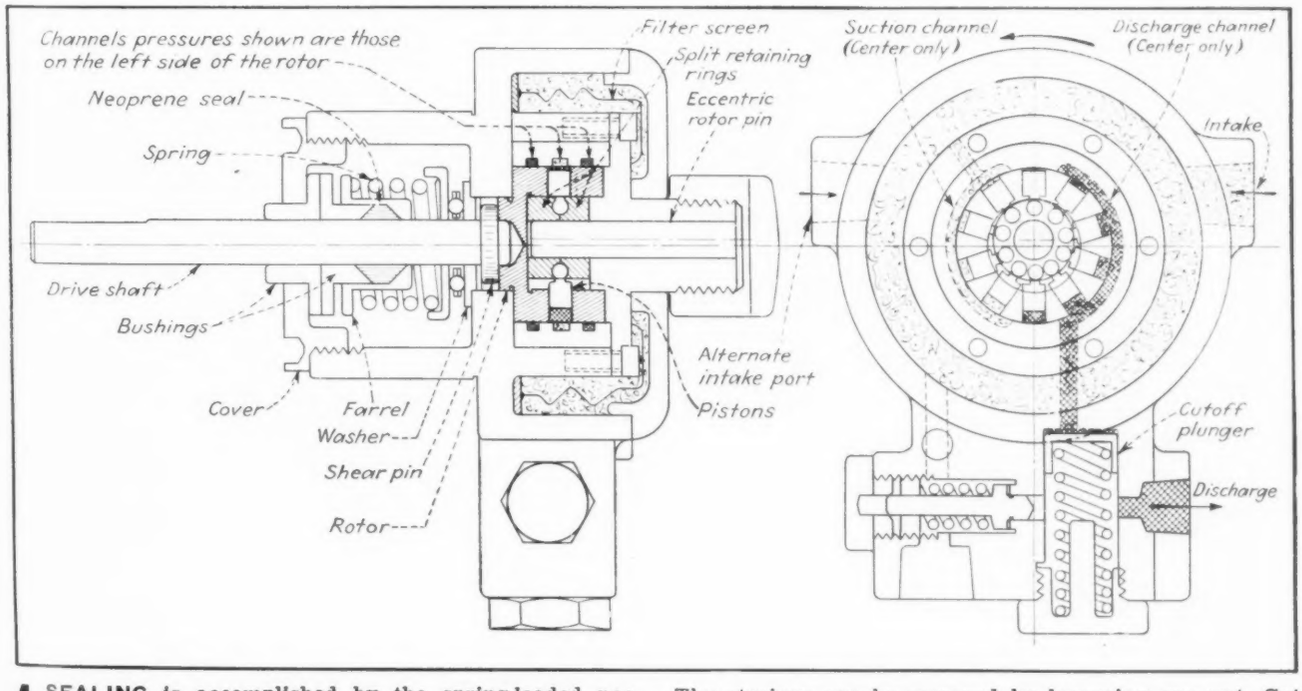
3 TWO SETS OF THREE CHANNELS form the suction and discharge lines around the stator bore, except for small top and bottom dead spaces. Inner channel on each side is connected to outer channels on other side as shown by Lucite model above. Areas are balanced so that the rotor has equal pressure and vacuum forces around its circumference.

Radial Piston Pump of Low Cost Design

Symmetrical parts that can be produced on automatic screw machines and turret lathes, except for gang milling of intake-discharge channels, reduce production costs. These channels are located around 340 deg of the stator to balance the pressures so that there is no radial thrust to cause binding and undue wear on rotor, pistons or pin.



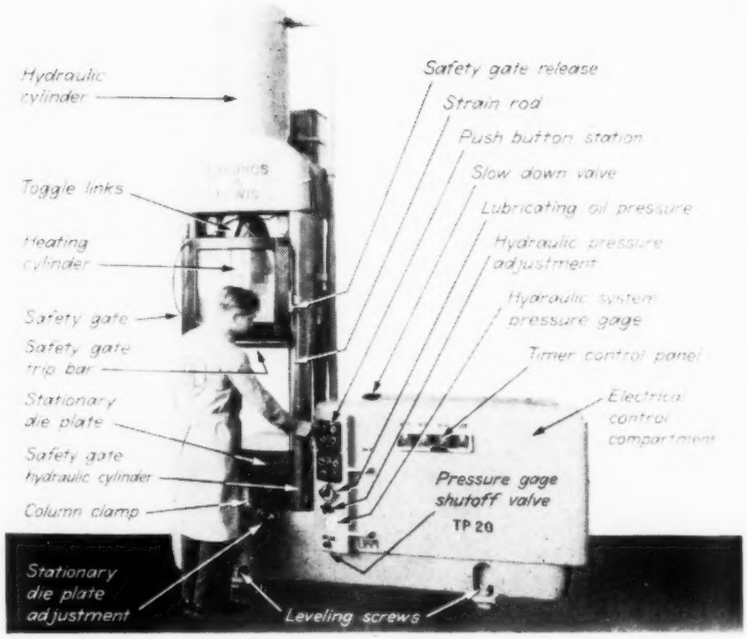
1 **PUMP OUTPUT** is 10 gph at 1,750 rpm, with pressures up to 250 psi using fuel oil. The design is by E. A. Cuny, Consulting Engineer for the Batco Domestic Oil Burner Pump Co., Quincy, Mass. It is claimed that the pump holds 2-4 in. of vacuum for 3-4 days, so priming is not lost. The small displacements provide a smooth pressure flow. Other models of this design have up to 32 pistons in single or staggered rows.



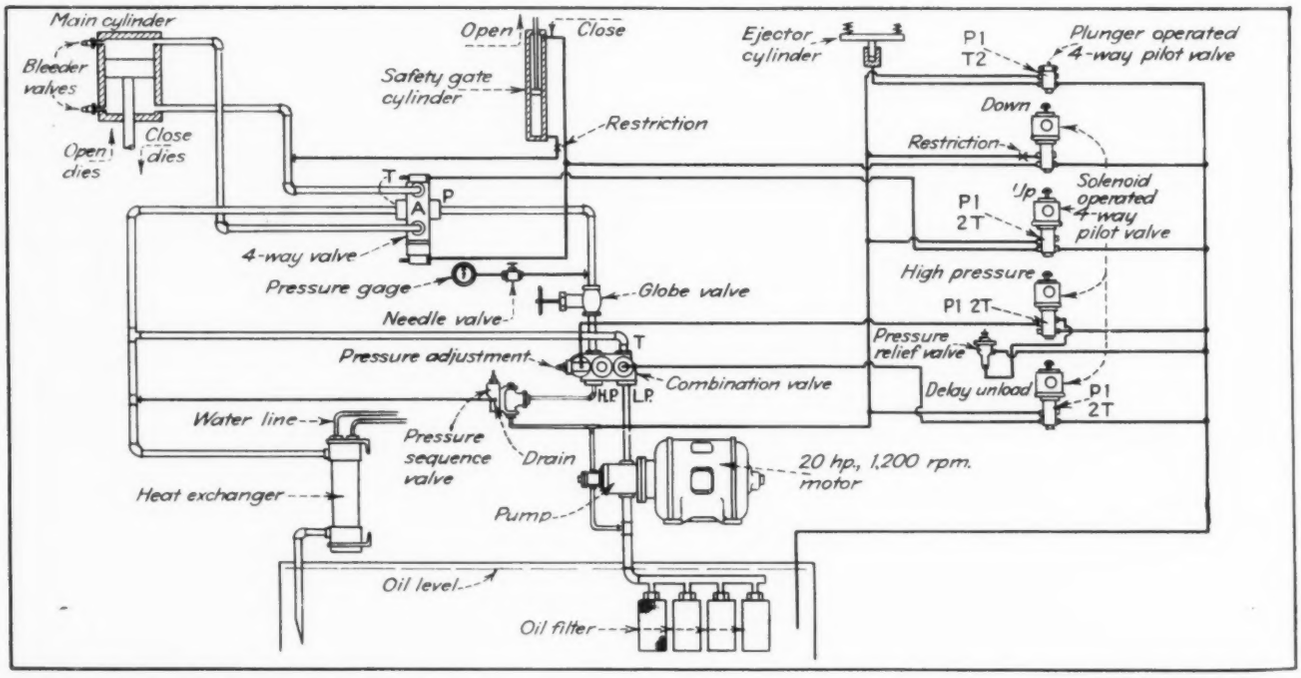
4 **SEALING** is accomplished by the spring-loaded neoprene washer held between the farrel and the inner bushing. Inner and outer bushing faces are ground to a close fit. Inner bushing is loose on the shaft to allow for misalignments. The spring is compressed between the washer that seals the rotor housing and the farrel. Thus sealing causes no axial or radial forces on the shaft. The strainer can be removed by loosening one nut. Cut-off plunger moves in when pressure ceases so that the resulting vacuum bleeds the burner line for rapid cut-off. Other models of this pump are used for metering, chlorinating, water pumping, high pressure coolant pumping, hydraulic power transmission and chemical proportioning devices driven by hydrostatic pressure.

One Hydraulic Cylinder Controls All Molding Operations

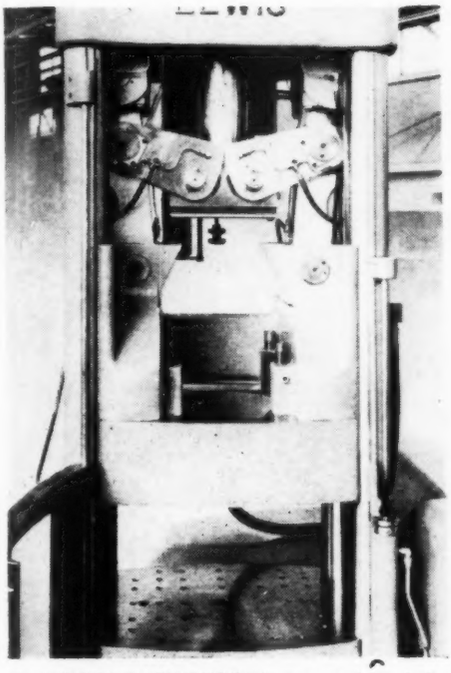
All die plate movements and injection of material into the mold cavities are controlled by one hydraulic cylinder in the TP-20 Vertical Injection Molding Machine built by Giddings and Lewis Machine Tool Co., Fond Du Lac, Wis. Capacity of the injection shot is 10 oz and maximum pressure is 23,000 psi. Electronic pyrometer controllers regulate temperature in upper and lower zones of quick-change heating cylinders.



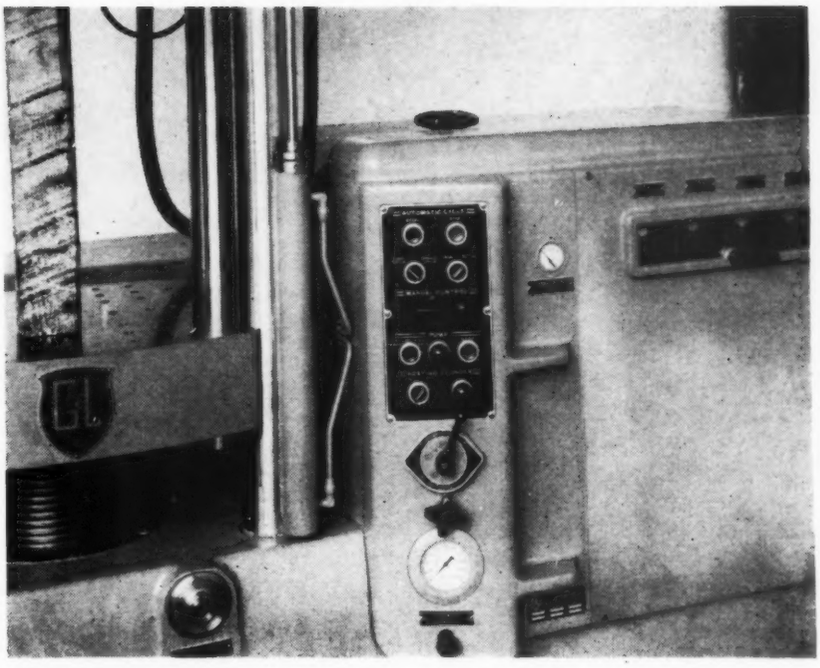
1 VERTICAL CONSTRUCTION facilitates handling of molds. A further advantage of this type of construction is that the weight of the die plates and molds does not cause the strain rods to sag as in horizontal designs. A hydraulically operated Bijur automatic lubricating system is used. Die plates are 23 in. by 29½ in. Mold opening is variable between 6 in. and 12 in. Machine has a total weight of 14,300 pounds.



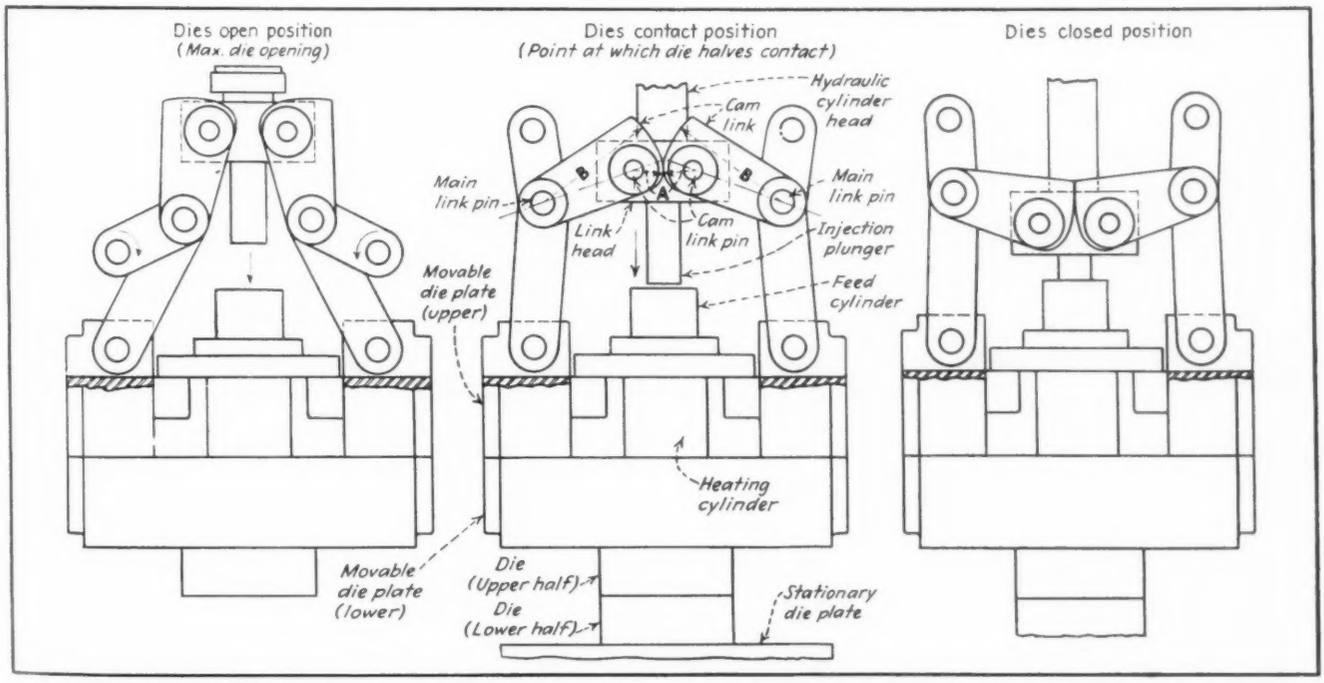
4 MAIN HYDRAULIC CYLINDER closes, clamps and opens the die plates. A second hydraulic cylinder is used to eject the finished piece from the mold. A third hydraulic cylinder is used for automatic operation of the safety gate. The safety gate and ejector cylinders are small and require no special controls to operate them. Injection speed and pressure are regulated by controlling the oil flow to the main cylinder. Four separate solenoid-operated four way valves regulate the flow of low and high pressure oil, direction of flow to the main cylinder and the delay unload operation. A heat exchanger in the return line to the tank is used to cool the oil. Vickers pump has a combined delivery of 60 gpm at 1000 psi pressure. Two covers at rear of machine provide accessibility to hydraulic units.



2 TOGGLE STRESSES are reduced by unidirectional toggle and injection pressures. Downward movement of the hydraulic piston sets the toggle mechanism and locks the die plates together. Continued movement injects plastic material into the die cavities.



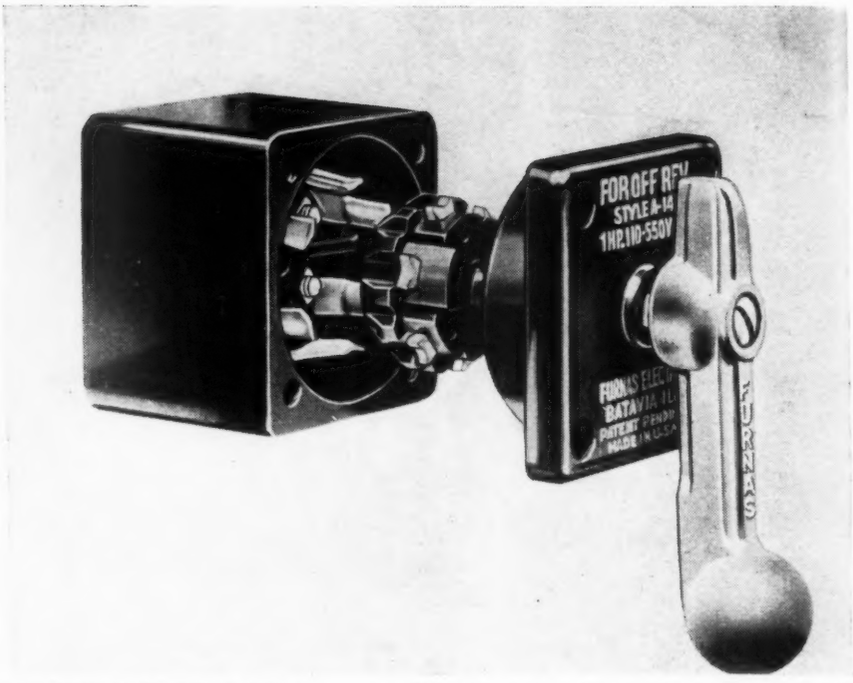
3 CONTROLS ARE PROVIDED for hydraulic, temperature regulating and electric systems. Temperature regulating system has electrical controls for regulating the temperatures of the heating cylinder. Temperatures of cooling water for the molds are similarly controlled. Electrical system controls the overall machine cycle time. Controls can be set for manual, semi-automatic or fully automatic operation. Maximum safety is provided by interlocking the controls.



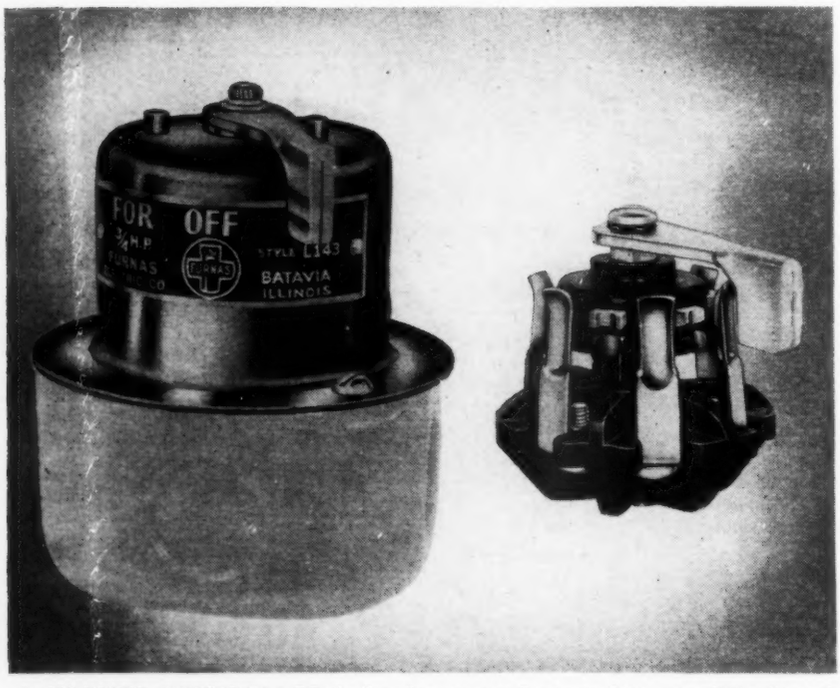
5 TOGGLE MECHANISM includes two cam links that have cam faces composed of two radii blended together to form a smooth face. Cam link pins are free to move in link head and thus permit the link pin centers to move apart. Second sketch shows position of cam links when die clamping pressure is first applied. Further downward movement of the piston rod causes the links to roll together and force the main link pins outward, thus applying clamping pressure by toggle action. Maximum pressure occurs when link head pin centers and main link pin centers lie in a straight line. From this point on, cam faces of radius "B" are in contact. Continued downward movement of the link head will produce no change in main link pin position during injection.

Switch Redesigned In Phenolic Plastics

Production cost has been reduced and exterior appearance improved by redesigning the motor control switches made by the Furnas Electric Co., Batavia, Ill. Molded from a phenolic plastic material made by the Durez Plastics and Chemicals Inc., North Tonawanda, N. Y., these switches are examples of savings made by using molded plastics.



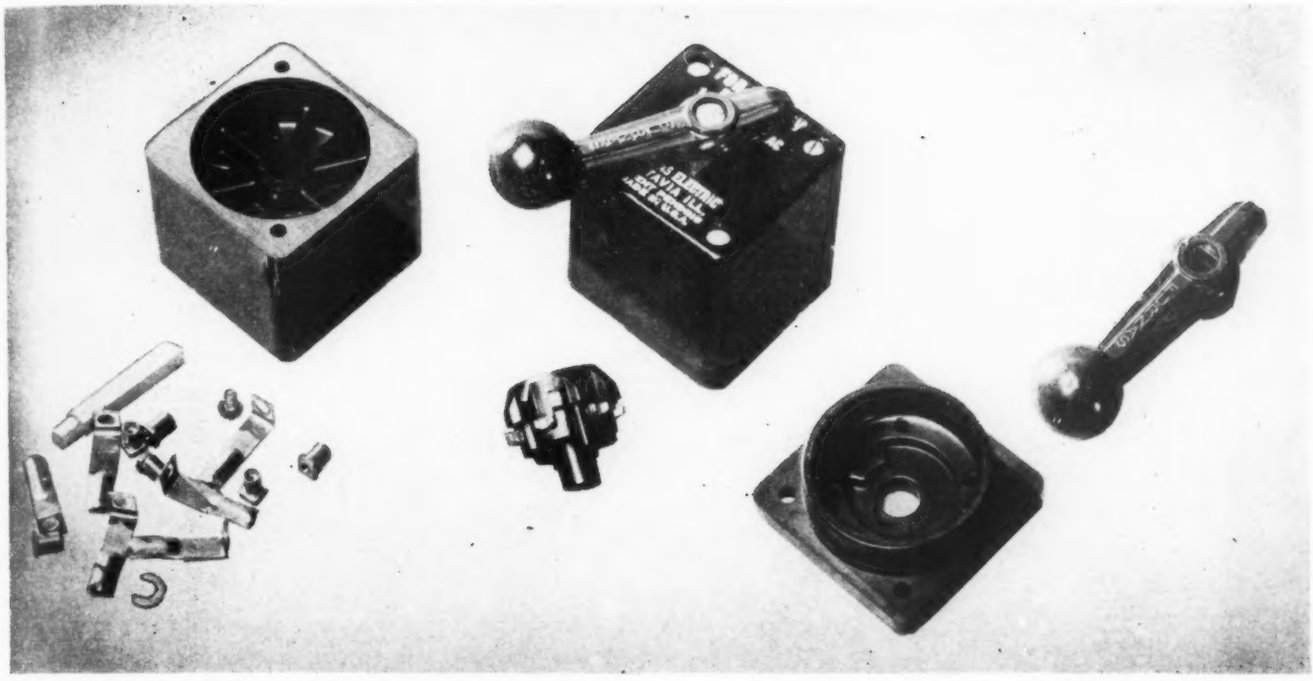
1 **NEW CONTROLLERS,** known as the "A" series, have a glossy black finish. The handles are red phenolic plastic with a molded-in steel insert that serves as reinforcement. These controllers are designed to mount on many different types of outlet boxes by using adapter plates. No insulating material is required since the phenolic material used in the switch is self-insulating. Controllers are made in four switching arrangements: reversing, two speed, series parallel and 3 pole off-on. Steel safety handles are optional equipment.



3 **FORMER CONTROLLER** had a drawn steel cover that was difficult and expensive to make. The switch lever stops were metal and located on the outside cover surface. These stops required a separate assembly operation. Main body of the switch was of molded phenolic plastic and the switch knob was metal. With this construction it was necessary to use an insulation within the cover, which required another separate assembly operation. Company nameplate was riveted to the cover.

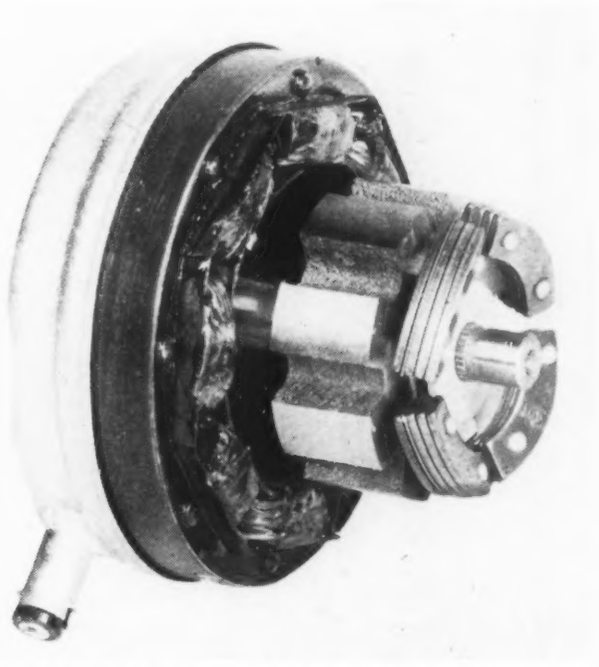
Small Generator Has Automatic Voltage Regulation

Small electric generators, manufactured by the Bendix Products Division of the Bendix aviation corporation, South Bend, Ind. as original equipment on motor bicycles and other small motorized vehicles have automatic regulation of voltage. They are driven by a friction disk that bears on the tire or flywheel.



2 SWITCH COMPONENTS include body, rotor, cover, and handle. Body is a one-piece plastic molded construction, which has molded terminal barriers and markings. Phosphor bronze stationary finger contacts are mounted by screws through holes in the body. The screws are used for the terminal connections on the under side of the body. Rotor is also plastic molded construction with molded-in copper contacts. The molded cover has matching recesses that position the rotor and act as stops for limiting travel. A square steel rotor shaft extends through the rotor and cover. It has a tapped hole in the end that receives the screw that mounts the handle. Cover, body and rotor are produced simultaneously in a multiple cavity die. Company nameplate data is molded in the cover.

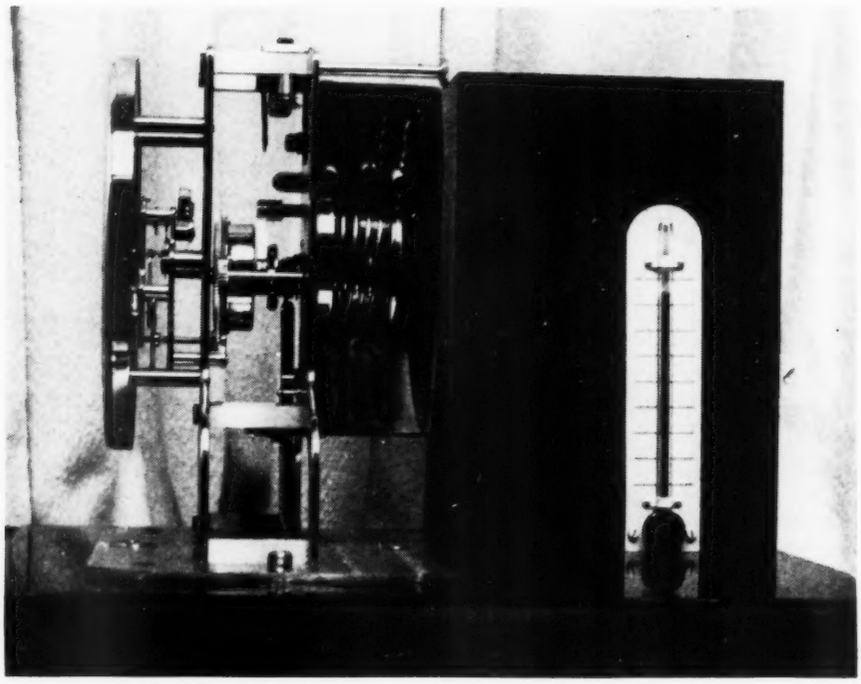
1 GENERATOR has 3½ in. outside dia and is 1½ in. thick. It develops 35 watts at 6 to 8 volts. Two integral assemblies are used for swivel mounting. No wearing parts such as commutators, slip ring or contacts are used. Rotor bearings are self lubricated Oilite. Friction disk is fastened to shaft by a wire pin that mounts in a drilled hole in the shaft.



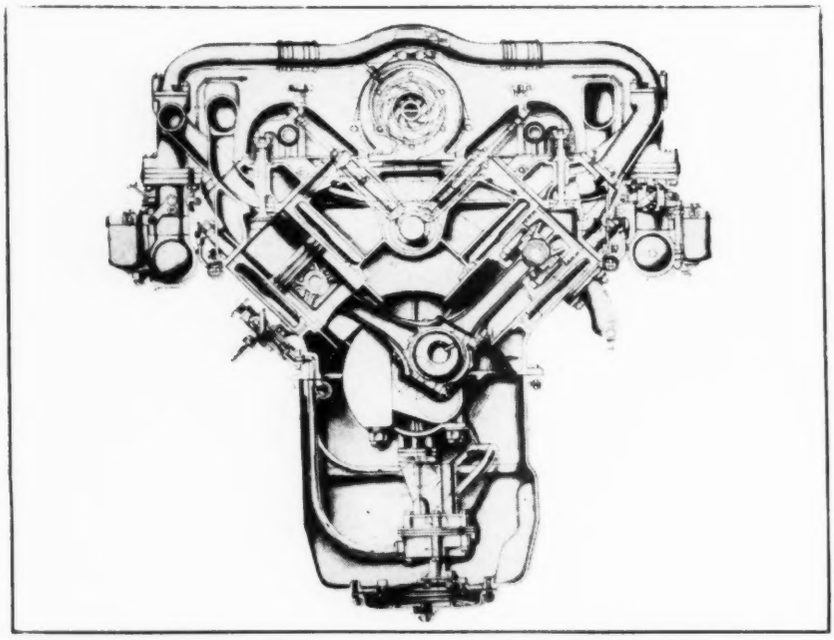
2 ROTATING MEMBER is an Alnico permanent magnet. Four segments are attached to the rotor shaft by separate spring steel leaves of different strength. At low speeds all segments are outside of field. As rotor speed increases, centrifugal force causes successive segments to extend to "short circuit" adjacent magnetic poles, thus giving automatic voltage regulation.

Heat Motor Automatically Winds Clock

The "Atmos" clock, made by Jaeger-Le Coultre, Geneva, will run indefinitely without winding. Energy source is derived from atmospheric temperature changes. Temperature change of 2F winds for 48 hr period.



1 CLOCK IS DESIGNED with low friction movement that has small energy requirements. A torsion pendulum is suspended by a wire and has no pivots. Barrel spring coils do not touch each other. All pinions have small outside diameters and their pivots are small. Ethyl chloride is used as the heat absorbing medium in the winding motor. All parts are metal. Movements are slow and thus no lubrication is required. Former clocks of this type used mercury sealed-in-glass for absorbing medium.

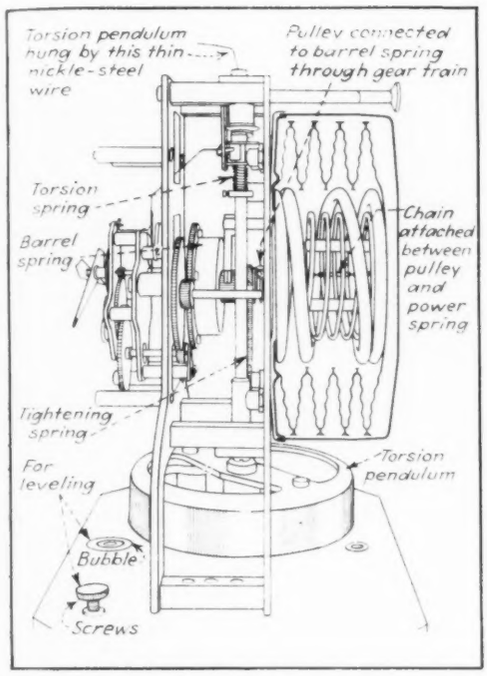


Unusual Automotive Construction

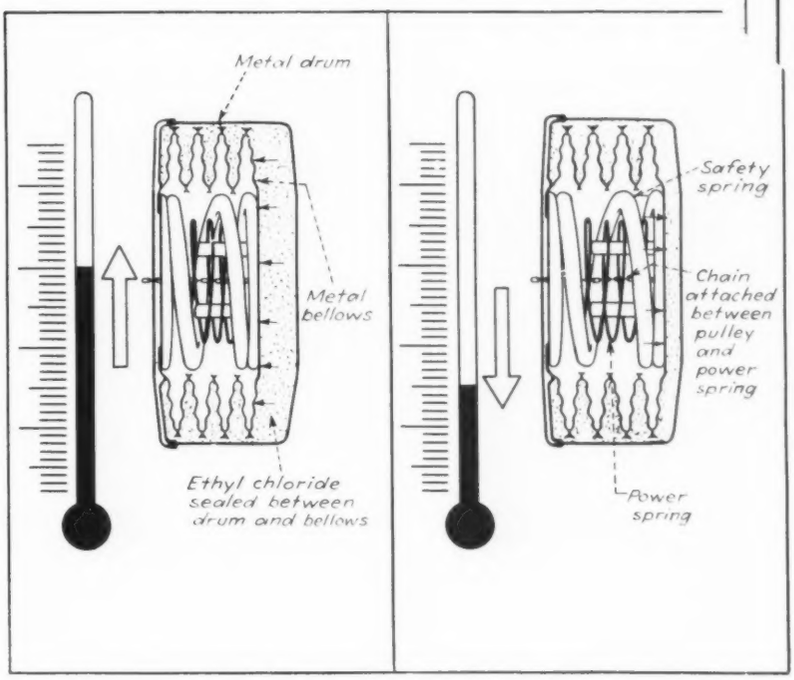
THIS V-8 German reconnaissance car engine has overhead valves set vertically in the engine, but at 45 deg to the cylinder axis. Apparently the purpose is to reduce overall height and width, as well as to shorten the pushrods to reduce inertia and rod deflections. Composite pistons have aluminum heads bolted to semi-steel skirts. Accessibility of oil filter screen and an opening in the pan large enough to permit withdrawal of the oil pump without engine removal are noteworthy design features.

Power Press Clutch has Safety Features

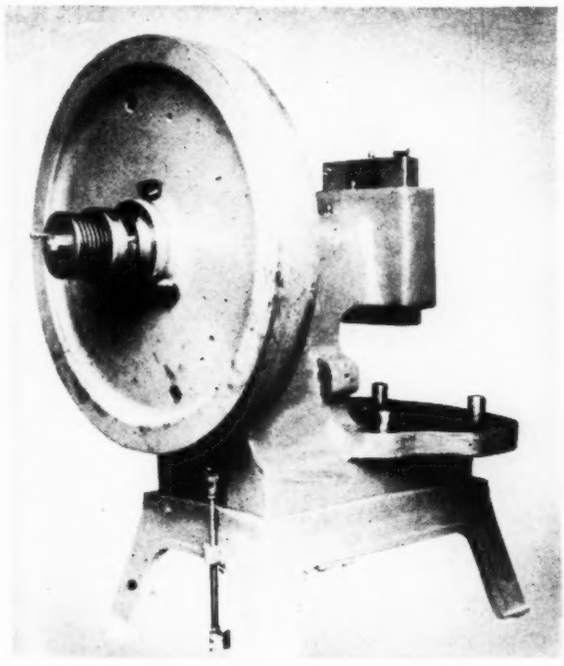
Designed for installation on power presses, the automatic clutch built by Walters and Dobson Ltd., Sheffield, can be set for single cycle or continuous operation. On single cycle, clutch will operate only once for each pedal depression.



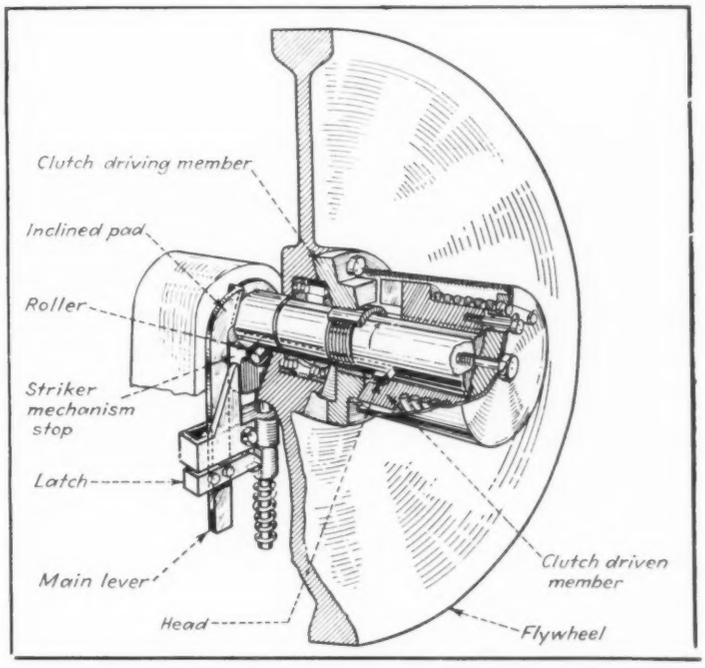
2 COMPONENTS INCLUDE a torsion pendulum, barrel spring geared to the heat motor and clock gearing. Clock is adjusted by adding weights to the pendulum. Finer adjustments are made by moving a pusher, which changes the length of the suspension spring under torsion.



3 TEMPERATURE INCREASE causes an increased vapor pressure in the ethyl chloride and the bellows contract. The chain then slackens and the tightening spring winds chain around the pulley. When temperature decreases, the power spring expands, resulting in a chain movement that winds the barrel spring. Safety spring prevents overcompression when temperature exceeds 80F. A three week period is required to put 1½ turns into the barrel spring.



1 FLYWHEEL is ball bearing mounted on main shaft extension. Jaw clutch driving member is bolted to flywheel. Clutch driven member slides on keys on mainshaft, and a spring forces clutch into engagement. Spring loaded pivoted jaws on driven member give added jaw clearance when clutch is disengaged. Sliding key pushes driven member out of engagement when pedal is depressed.



2 CLUTCH IS OPERATED by depressing pedal, which pulls striker mechanism stop from engagement with roller on end of clutch actuating rod, and spring engages clutch. For single cycle operation the inclined pad is set to engage main shaft surface and disengage clutch from stop. Stop then re-engages roller, and clutch disengages. Thus the cycle can only be initiated by re-depressing pedal. For continuous operation the pad is set away from shaft.

Acceleration of Inertia Loads With a Varying Torque

JAMES D. BURBY
Consulting Engineer

Methods for calculating the time required to accelerate a rotating inertia load by a torque that can be defined or approximated as a function of speed. Time-speed characteristics are computed by an analytical method, an arithmetical integration method, and from area under a reciprocal torque-speed curve.

IN PROBLEMS dealing with the time-speed characteristics of rotating inertia loads, the time required by a varying torque to produce a given change in the angular velocity of an inertia load can be calculated from the torque-speed curve of the prime mover. The problem sometimes includes dealing with a varying moment of inertia and the effects of loads not resulting from inertia.

Many typical examples can be cited: An electric motor when coming up to speed or starting from zero speed that must accelerate a rotating mass, a flywheel, a heavy mechanism for rotating ingots, or a fast acting actuator for aircraft.

In this discussion the variable torque will be assumed to be defined as a function of speed by a motor torque-speed curve, obtained by test or derived from design data.

Where

M = instantaneous value of net torque available for acceleration, lb. ft.
I = moment of inertia of rotating parts, lb. ft. sec.^{2}
α = angular acceleration, radians per sec.^{2}
ω = varying angular velocity of motor, radians per sec.
t = time required to change ω from an initial value of ω_1 to a final value of ω_2, sec.

the solution of problems of the types mentioned includes the solution of the general equation

$$M = I\alpha = I\frac{d\omega}{dt} \qquad (1)$$

The analytical solution of Equation (1) requires that M be expressed as a mathematical function of ω. Assuming that such a function is obtainable from the torque-speed curve in the form

$$M = F(\omega)$$

there results the differential equation

$$dt = I\,\frac{d\omega}{F(\omega)}$$

or

$$t = I\int_{\omega_1}^{\omega_2}\frac{d\omega}{F(\omega)} \qquad (2)$$

Under the conditions that I is constant and that no torque is expended for any purpose other than to accelerate I, Equation (2) is valid.

Electric motor torque-speed curves are not, in general, expressible by simple mathematical functions, at least not over their whole range, but to illustrate the analytical application of Equation (2), the curves shown in Fig. 1 will be assumed. The small circles in Fig. 1 are point sets taken from a steady-state torque-speed test curve for a direct current series type motor. The superimposed curve AB is a portion of the "graph" of the function

$$M\omega^3 = 1.046 \times 10^9 = \text{parameter } P \qquad (3)$$

The correspondence between the test data and the curve AB is probably as good as will ordinarily be obtained for a torque-speed relation; nevertheless the correspondence is not exact.

When full line voltage is impressed on the motor terminals, the shape of the actual curve beyond point A is a smooth continuation of AB that is satisfactorily represented, for the purpose of this article, by the straight line M_sA. The intercept on the torque axis is at M_s, the zero-speed, or stalled, torque. The intercept on the speed axis shown by extrapolation to be at Ω. Ω is the terminal speed that the motor would approach if the straight line $M_s\Omega$ correctly expressed the torque-speed relation to that point.

The equation of the straight line $M_s\Omega$ is

$$M = M_s - \omega\tan\beta$$

This equation defines M as a function of ω By substituting in Equation (2), and noting that $\tan\beta$ equals M_s/Ω, the following integral expression is obtained for t over the interval 0 to ω,

$$t = I\int_0^{\omega}\frac{d\omega}{M_s-(M_s/\Omega)\omega} \qquad (4)$$

or

$$t = \frac{I\Omega}{M_s}\log_e\left(\frac{\Omega}{\Omega-\omega}\right) \qquad (5)$$

For the purpose of facilitating numerical computations, let the particular value of ω for which t is required, be expressed as a fraction of Ω, thus:

$$\omega = K\Omega \qquad (K<1)$$

Then Equation (5) can be written in the form,

$$t = \frac{I\Omega}{M_s}\log_e\left(\frac{1}{1-K}\right) \qquad (6)$$

If values of K are assumed and values of

$$\log_e\,[1/(1-K)]$$

are plotted, the curve of Fig. 2 results. By using values of the logarithmic function obtained from the curve, the calculation of t can be facilitated.

EXAMPLE. Given a straight line torque-speed relation as defined by $M_s\Omega$, Fig. 1.

$$\Omega = 9{,}000 \times \frac{2\pi}{60} = 942.48 \text{ radians per sec.}$$

M_s = 20 lb. ft.
WR^2 = 1.3 lb. ft.^{2} at the motor shaft

$$I = \frac{WR^2}{g} = \frac{1.3}{32.16} = 0.0404 \text{ lb. ft. sec.}^2$$

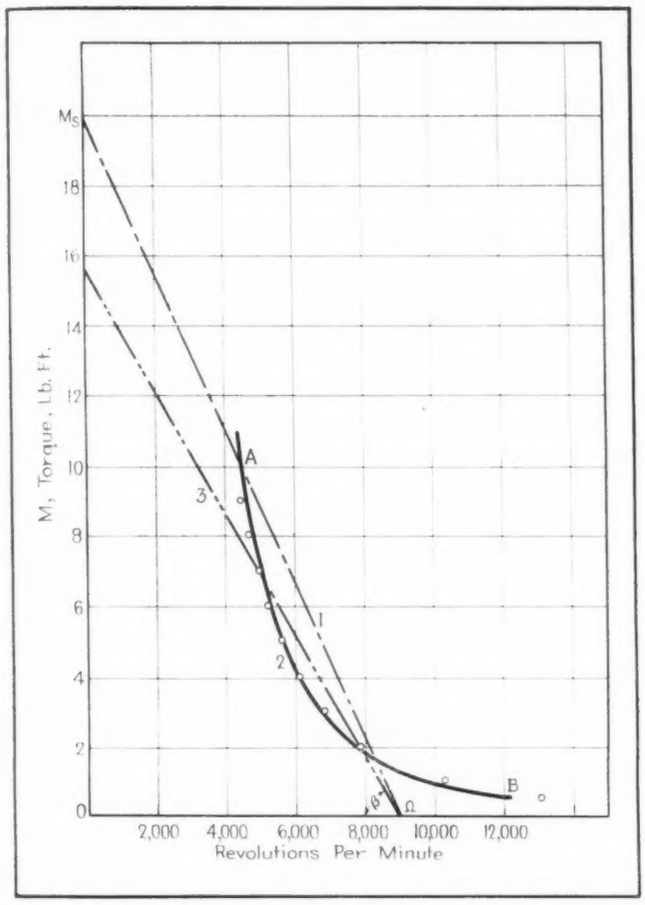


Fig. 1—Steady-state torque-speed test curve for a d-c series type motor. The ten small circles indicate test point sets.

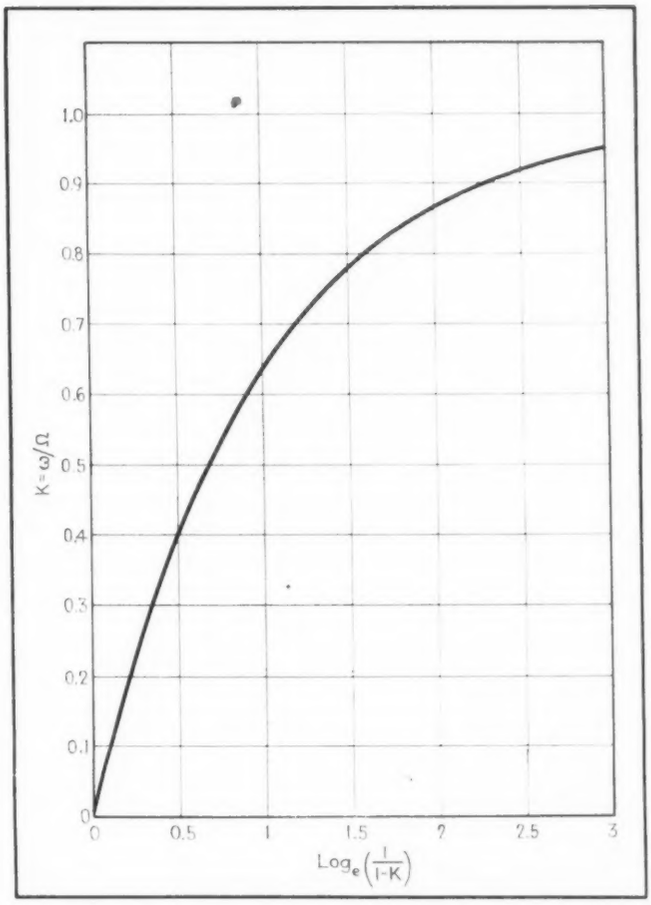


Fig. 2—Values of logarithmic function for ratios of angular velocity to terminal speed to facilitate time calculations.

Find the time t required by the motor to speed up from zero to 4,500 r.p.m.?

SOLUTION:

$$\omega = \frac{4{,}500 \times 2\pi}{60} = 471.24 \text{ radians per sec.}$$

$$K = \frac{471.24}{942.48} = 0.50$$

$$\log_e\left(\frac{1}{1-0.50}\right) = 0.692 \text{ (from Fig. 2)}$$

$$t = \frac{0.0404 \times 942.48 \times 0.692}{20}$$

$$= 1.32 \text{ sec.}$$

Note that the ordinates K of Fig. 2 represent angular velocity ω, to the scale $K\Omega$. That is, in the previous example a K of 0.50 represents an angular velocity of 4,500 r.p.m. Similarly, the abscissas represent time t to a suitable scale that depends upon the values of the parameters in Equation (6). For the preceding example, 1.905 times the value of any abscissa is the time in seconds required to reach the angular velocity represented by the corresponding ordinate to its scale.

The curve of Fig. 2 therefore represents, with suitable scales, the speed-time relation where the torque is a straight line function of the speed. It follows that the area under any portion of the curve represents, to a proper scale, the angular displacement for the time interval corresponding to the abscissas that determine the area.

Let it be required to find the time necessary to change the speed of the inertia load in the previous example from 4,500 to 7,000 r.p.m., "along the curve AB", the equation of which was found to be

$$M\omega^3 = 1.046 \times 10^9 = P$$

Transposing and substituting in Equation (2).

$$t = \frac{I}{P}\int_{\omega_1}^{\omega_2} \omega^3 \, d\omega$$

or

$$t = \frac{I}{4P}(\omega^4{}_2 - \omega^4{}_1) \qquad (7)$$

ω_2 = 7,000 r.p.m. = 733 radians per sec.
ω_1 = 4,500 r.p.m. = 471 radians per sec.

$$t = \frac{0.0404}{4 \times 1.046 \times 10^9}(733^4 - 471^4)$$

$$= 2.32 \text{ sec.}$$

Thus, the total time required to bring the inertia load I up to a speed of 7,000 r.p.m. along the torque-speed curve M_1AB, Curve 2 of Fig. 1, is

$$t = 1.32 + 2.31 = 3.63 \text{ sec.}$$

This result is mathematically exact for the curves chosen and for the conditions under which Equation (2) was stated to be valid. In view of the difficulty often surrounding the assignment of mathematical formulas to curves of the type approximated by curve AB in Fig. 1, the question arises as to whether a sufficiently exact answer might not be obtained by assuming a straight line curve throughout.

The obvious first trial is Curve 1 of Fig. 1 and, by means of Equation (6) and Fig. 2, it is found that a speed of 7,000 r.p.m. is reached along this curve in 2.86 sec., which is 21 percent less than the correct time. As a second approximation, the line through Ω, 9,000 r.p.m., which makes t equal to 3.63 sec. at 7,000 r.p.m., might be tried. By substituting these known values in Equation (6) and solving, M_s is found to be 15.8 lb. ft., and the line through that intercept and Ω is

shown as Curve 3, Fig. 1. The speed-time graphs calculated from each of the three curves are plotted in Fig. 3, from which the degree of approximation becomes readily apparent.

It should be kept in mind that from a given torque-speed curve, only one speed-time curve can be obtained by integrating Equation (2); and that speed-time curve is the only one that exactly represents the motion. The extent to which an approximation, such for example as Curves 1 or 3 of Fig. 3, will suffice depends entirely upon the particular circumstances.

All doubts as to the sufficiency of an approximation, as well as many of the difficulties attendant upon the analytical solution of Equation (2), may be avoided by using an arithmetical method for the integration of an actual $M\omega$ curve. The latter method not only is simpler to apply, but when the curves are complicated it is less time consuming. Moreover, this method can be applied where I is not constant and where forces not resulting from inertia must be included.

To develop the concept of the method, let Equation (1) be taken in the form

$$M = I\frac{d\omega}{dt}$$

and substitute $\Delta\omega/\Delta t$ for $d\omega/dt$, with the understanding that the ratio of the finite increments will be accepted as a satisfactory approximation to the ratio of the differentials. Making the substitution, transposing, and using the subscript i to indicate a certain interval of time Δt_i, during which time the inertia load I will receive an increment of angular velocity $\Delta\omega_i$ that results from the action of the torque M_i, the value of the torque M_i may be regarded as an average value that prevails during the whole of the interval, then Equation (1) becomes

$$\Delta t_i = \frac{I\,\Delta\omega_i}{M_i} \qquad (8)$$

Let i take on the successive values 1, 2, 3, and so on, then form the corresponding summation

$$\Delta t_1 + \Delta t_2 + \Delta t_3 + \ldots \Delta t_n = \frac{I\Delta\omega_1}{M_1} + \frac{I\Delta\omega_2}{M_2} + \frac{I\Delta\omega_3}{M_3} + \ldots \frac{I\Delta\omega_n}{M_n}$$

Obviously, the sum on the time intervals is the total time t required for the overall change in angular velocity

$$\Delta\omega_1 + \Delta\omega_2 + \Delta\omega_3 + \ldots\ldots \Delta\omega_n$$

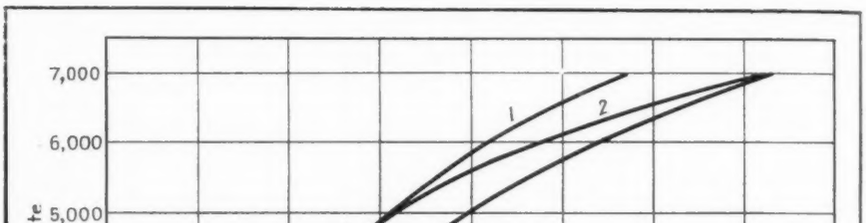


Fig. 3—Speed-time graphs for comparing results as obtained by three curves.

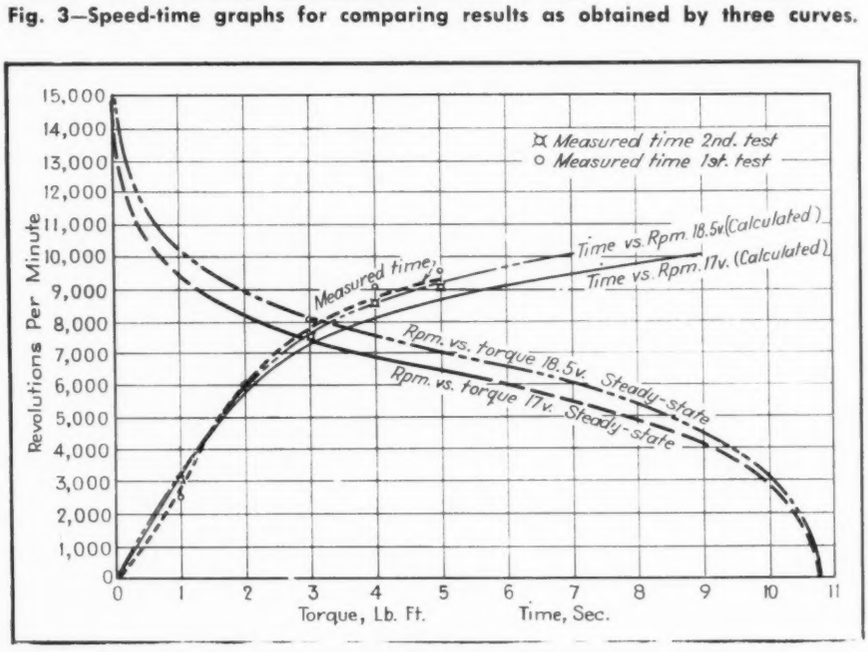


Fig. 4—Comparison of curves obtained by arithmetical integration and by measured time tests confirms reliability of arithmetical integration.

The equation may be written in the form,

$$t = \sum_{i=1}^{i=n} \frac{I\Delta\omega_i}{M_i}$$

From the mathematical standpoint, if the number of terms is increased without limit, while the largest velocity increment approaches zero with the increase in the number of terms, the result of the summation will be precisely that which would be obtained by the formal integration of Equation (2), for any given function.

From the practical standpoint, the number of terms need be only relatively few to secure at least as good an answer from an actual curve as can be obtained by an "exact approximation" of an assumed curve.

To illustrate the application of the arithmetical integration method, the data for a time-speed curve will be calculated from Curve MAB of Fig. 1 for the same value of I previously used.

Assume four equal intervals corresponding to the change in angular velocity from zero to 4,000 r.p.m. and six equal intervals between 4,000 and 7,000 r.p.m. as indicated by the

increments $\Delta\omega_i$ in Column 2 of Table I. At the midpoint of each velocity increment, estimate the corresponding value of torque from the torque-speed curve and enter it in Column 3. For each interval, calculate the value of the quotation $\Delta\omega_i/M_i$ and enter the result in Column 4. In Column 5, enter the products of these quotients times the value of I, assumed to be constant. In Column 6 enter the cumulative totals of the products, representing $\Sigma\Delta t_i$. The cumulative time values are tabulated in Column 6 to facilitate the plotting of a speed-time curve.

As indicated in the table, the times for the two sub-intervals 0 to 4,500 r.p.m. and 4,500 to 7,000 r.p.m. agree with the values previously found by formal integration. For closer comparison, the times calculated from Equations (6) and (7) for each interval are tabulated in Column 7 on a cumulative basis.

A further check on the reliability of the arithmetical integration method is furnished by the curves on Fig. 4. Those marked "R.p.m. vs. Torque, 17 V." and "R.p.m. vs. Torque, 18.5 V." are $M\omega$ curves for another small direct current motor. They represent steady state conditions for the respective voltages. Curves marked "Time vs. R.p.m., 17 V." and "Time vs. R.p.m., 18.5V." were computed by the arithmetical integration method, using 12 intervals. The motor turned a flywheel having a WR^2 of 26.36 lb. ft.^{2} through a gear ratio of 1 to 5.143 interposed between flywheel and motor. Mechanical losses were neglected.

Table I—Procedure for Arithmetical Integration

1	2		3	4	5	6	7
Interval i	$\Delta\omega_i$ r.p.m.	$\Delta\omega_i$ radians per sec.	M_i	$\Delta\omega_i/M_i$	$I(\Delta\omega_i/M_i)$	$\Sigma\Delta t_i$	$\Sigma\Delta t$, by Eq. (6) & (7)
1	1,000	104.72	18.90	5.54	0.224	0.224	0.224
2	1,000	104.72	16.67	6.28	0.254	0.478	0.479
3	1,000	104.72	14.45	7.25	0.293	0.771	0.772
4	1,000	104.72	12.23	8.56	0.346	1.117	1.120
5	500	52.36	10.58	4.95	0.200	1.317	1.320
6	500	52.36	8.40	6.23	0.252	1.569	1.570
7	500	52.36	6.30	8.31	0.336	1.905	1.907
8	500	52.36	4.80	10.91	0.441	2.346	2.349
9	500	52.36	3.73	14.04	0.568	2.914	2.918
10	500	52.36	2.97	17.63	0.713	3.627	3.633

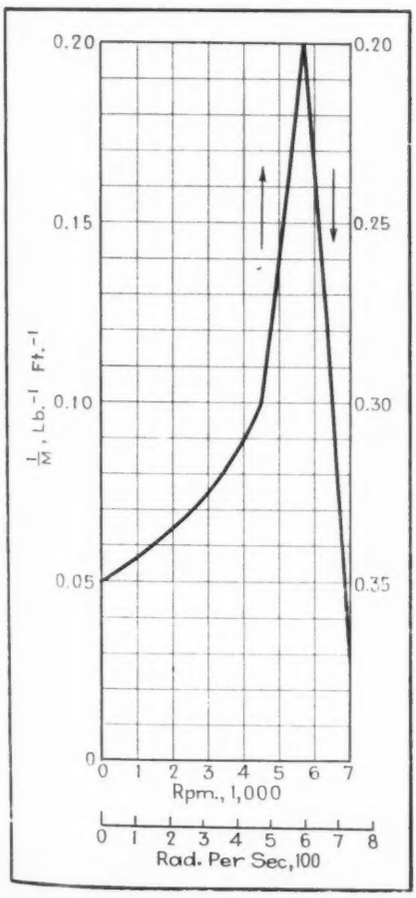


Fig. 5—Inverse torque speed curve plotted on a base of angular velocity.

The circles, Fig. 4, indicate measured times obtained in two laboratory tests of this motor with flywheel and gears. The tests were made at a generator open circuit voltage of 19. During the tests, the voltage fluctuated from approximately 12 volts for the first second to an average 18.9 volts for the fourth second.

Another means of making possibly even closer predictions of time-speed behavior is suggested by the steady state torque-speed curves. In these the voltages can be varied in accordance with a pre-established pattern determined by experience.

It may be of interest to investigate the area defined by Equation (2). This area is not the area under the torque-speed curve, obviously, but rather the area under an inverse torque-speed curve obtained by plotting values of ω against values of $1/M$. The area under this curve has the dimensions

$$\frac{1}{\text{lb. ft.}} \times \frac{1}{\text{sec.}}$$

If such an area is multiplied by the dimensions of moment of inertia, the result is time, thus:

$$\frac{1}{\text{lb.ft.sec.}} \times \text{lb. ft. sec.}^2 = \text{sec.}$$

If the area under such a reciprocal torque-speed curve is multiplied by moment of inertia, the result represents the time required to effect the corresponding change in the angular velocity.

The curve of Fig. 5 was plotted in this fashion from the data of the curve M_cAB of Fig. 1. The scale of unit area times unit I in Fig. 5 is 4.19 sec. per sq. in. The area under the curve from zero to 4,500 r.p.m. is 7.77 sq. in. The area under the curve from 4,500 to 7,000 r.p.m. is 13.64 sq. in. The WR^2 equals 1.3 lb. ft.^{2} Therefore, the times in which the respective changes in angular velocity occur are

$$t_1 = 4.19 \times 7.77 \times \frac{1.3}{32.16} = 1.32 \text{ sec.}$$

$$t_2 = 4.19 \times 13.64 \times \frac{1.3}{32.16} = 2.31 \text{ sec.}$$

$$t_1 + t_2 = 1.32 + 2.31 = 3.63 \text{ sec.}$$

This area concept offers another approach, one that may be helpful in solving problems dealing with the acceleration of equipment such as wire drawing machines and spoolers driven by wound rotor induction motors, where acceleration is controlled by a stepwise change in secondary resistance. A curve for this type of torque-speed relation can be treated by either the arithmetical integration or area integration methods, depending upon the requirements of the problem and the preferences of the engineer.

In conclusion, it may be briefly mentioned that a variable moment of inertia, and a non-inertia load, both may be taken into account quite readily by the arithmetic integration method. It is necessary only to alter the torque-speed curve to suit the conditions of non-inertia loading, and to insert the appropriate values of the varying moments of inertia in the products $I_i\Delta\omega_i/M$ to satisfy the conditions of the imposed loading.

Progress IN REVIEW

PLASTICS

A scratch-resistant surface has been developed for polystyrene that provides 18 percent greater wear-resistance than standard polystyrene and is slightly better than a good spar varnish finish. In addition, as reported in *Plastics News Letter,* Sept. 29, 1947, the surface is less electrostatic and is easier to polish to clearness. This surface is craze-resistant to most solvents that attack untreated polystyrene. The treatment, as mentioned in the Oct. 1947 issue of *India Rubber World,* was developed for production line application and requires no special equipment. The treatment, complete in 15 min., is claimed to form an actual fusion between the polystyrene and the scratch-resistant material. Because of this fusion, this coating cannot be peeled off.

Mechanical combinations of plastics with other types of materials, long advocated on a theoretical basis, are now finding extensive application. In England, a sandwich laminate is combined with extruded aluminum quadrant cemented joints and facings to produce modern bookcases. As mentioned in the Sept. 1947 issue of *Plastics* (London), these bookcases are designed for optimum utility and eye-appeal. Extruded cellulose acetate butyrate, in combination with a bead molding that has a front facing of polished stainless steel, is used for interior body trim in new Mercury cars. Also mentioned in the Oct. 1947 issue of *Plastics* is a steering wheel molded from 5 lb. of tenite molding powder and a steel insert. In this design, the metal supplies strength and rigidity, while the plastic provides toughness, beauty, pleasant touch, permanent color and appearance. Unlike rubber, this steering wheel will not stain the hands or gloves.

Saran-lined steel pipe for corrosion resistant service is now produced at a price equivalent to the present corrosion-resistant pipe but with greater strength. This plastic material will resist acids up to 190 F, according to *Plastics World,* Oct. 1947. For similar service, an acid-resistant neoprene paint that can be applied to metals, wood and other materials without special surface treating has been developed. This paint is odorless, abrasion-resistant, dries completely in a few hours, and adheres well to smooth surfaces. This paint will have many industrial uses as mentioned in an article in the Sept. 1947 issue of *Rubber Age.*

Mechanical combinations and physical contacts of two or more different plastic types have been investigated. The investigation was conducted to determine which plastics cannot be placed in actual contact. As reported in *Modern Plastics,* Oct. 1947, polystyrene-acrylic and cellulose acetate-vinyl chloride laminations appear to be successful in packaging uses. However, cellulose acetate and polystyrene must not be allowed to touch each other; the plasticizer from the former may fog the latter if the item gets hot. It has also been found that vinyl garments hung on polystyrene coat hangers can absorb some of the color from the styrene. This investigation has disclosed an interesting analogy between the use of plastics and metal-plating techniques. In trying to find a substitute for oilcloth it was found that a coated paper could be made both colorful and launderable. However, the vinyl chloride would not stick to the paper. To improve the adhesion characteristics, the paper was first coated with a nitrile synthetic rubber.

Resin-paper laminates, thoroughly seasoned to equilibrium dimensions before fabrication, are used to make slide rules and drawing boards in Great Britain. According to the Oct. 1947 issue of *Plastics* (London) there is no need for springs or adjustment grooves usually needed to compensate for wear of the parts. These slide rules do not warp, and falls to the floor will not harm them. Resin-paper laminates, originally developed for war uses, are now finding industrial applications. Light-weight shipping containers made from this material have the strength of wooden boxes. As described in the Oct. 1947 issue of *Plastics World,* these boxes are available in sizes up to 20 ft. long. The resin-paper laminates can be sawed, stapled or nailed without splitting or splintering.

Molded methyl methacrylate and polystyrene lenses and mirrors may pave the way for low-cost television sets. As mentioned in *Modern Plastics,* Oct. 1947, grinding and polishing of the present glass parts is a slow and very expensive process. Other molded thermoplastics have made possible low-cost miniature radios. One model, 4⅜ x 3 x 3 in., is equipped with small batteries, earphone reception, and special condenser claimed to give reception as fine as with standard size sets.

Heat-sealing of normal gage thermoplastic films is very common, but with very thin films, the cost is often prohibitive because of extremely high power consumption. The Sept. 1947 issue of *Plastics* (London) presents a discussion of the theory involved, data for tests made, and suggestions for eliminating the high cost. Heated electrodes or the use of thermal insulation between the electrodes and the power supply have been suggested as remedies.

Plastic battery separators are under investigation in the United States and Great Britain. The English Porvic, polyvinylchloride, battery separators have greater acid and oxidation-resistance than wood or hard rubber. Considerable research was necessary to obtain the desired porosity to permit necessary diffusion. In America, pulp-phenolic resin type plastics are being tried. The desired porosity is obtained by proper control of the paper production and resin impregnation.

Vinyl coatings are sprayed on each new Flying Wing airplane to provide a temporary abrasion and corrosion-resistant shield for the wing surfaces during the interval between end of assembly line and delivery to customer. During motor assembly, adjustment and pre-flight

tests, mechanics are liable to walk on wing surfaces or drop tools on them. About 65 gal., as mentioned in the Oct. 1947 issue of *Modern Plastics,* are used for each plane. Three coats, totalling 0.01 in., produce a film that is tough, and resilient, but which can be peeled off in a few minutes when desired.

Lumber and plywood scarcity in England has accelerated the development of a core made from a combination of 10 percent cresol-formaldehyde resin and 90 percent sawdust waste. The core is used in fabricating sandwich-type wallboard. All kinds of wood can be used in this process because the components are blended dry and cold. In the United States, where liquid resins are generally used, only a few types of wood can be used because of impregnation difficulties. Boards, 48 in. wide and of any density and thickness, can be made at the rate of 2 ft per min in a continuous press described in *Modern Plastics,* September 1947. The materials are heated by a combination of the high frequency and infra-red techniques. In the formation step, pressures of 50 psi are used for making the core. The cores and skins are joined with 300 psi pressure. Water absorption and spread-of-flame rates are such that the material can be used for living rooms, bedrooms or escape passages.

Ion exchange resins, as reported in *Industrial and Engineering Chemistry,* September 1947, are being used to recover malic acid from the impurities removed from apple syrup. In line with this is a discussion in the September 1947 issue of *Modern Plastics* concerning the successful use of Amberlite resins in the treatment of ulcers. The resins absorb the excess hydrochloric acid from the stomach and later release it harmlessly in the intestine. It is claimed that pain is quickly relieved when one of the pills is swallowed, and that no harmful effects have been observed.

The Fischer-Tropsch process for producing oil and gasoline from coal will also yield large quantities of byproducts useful to the plastics industry. Alcohols, ketones, acids, aldehydes and esters—estimated at 300 million pounds annually—will be available at low prices for use as reactants, solvents or plasticizers.

Hycar nitrile rubber combinations with polyvinyl chloride resin are now commercially available as colloidal blends. These Geon Polyblends are said to combine the solvent resistance and flexibility of the rubber component with the toughness and chemical resistance of the polyvinyl chloride. As indicated in the September 1947 issue of *Modern Plastics,* the Polyblend can be used as a thermoplastic material with the nitrile rubber functioning as a non-migrating, non-extractable, non-evaporating polymeric plasticizer. Applications include electrical insulation, ladies' handbags, shoe uppers, bookbindings, and tubing and hose that will not stiffen with age. If greater strength and better resistance to heat and solvents are desired, the Hycar can be vulcanized. In this form, it has been used as football covers and as printing roll covers.

Brake linings cemented to the brake shoe with a rubber-containing adhesive have produced units with greater strength than possible by the rivet method. According to the September 1, 1947 issue of *Plastics News Letter,* one of the resins will resist a shearing pull of 10,000 lb, while brass rivets begin to give at 3,500 lb and fail at 5,000 pounds. In addition, the new process is less expensive, permits a larger contact area, permits longer periods between relining and reduces scoring of the drum. The process is simple enough to be done in repair garages.

Chlorinated styrene rubber is believed to more closely match the qualities of natural rubber, in tire use, than any of the synthetics previously developed. Actual road tests, reported in the August 1947 issue of *Rubber Age,* reveal less sidewall cracking, better heat-resistance and longer wear than similar tires made from standard GR-S synthetic rubber. The same magazine mentions that truck tires with wire cord fillers are being tested. It has been found that these tires have strength and run at lower temperatures than present tires, and it is claimed that they give enough more mileage to offset the slightly higher initial cost.

Extrusion, previously limited to the processing of thermoplastic materials, was used in manufacturing thermosetting plastic rocket tubes during the recent war. The newest use for tubing extruded from phenolic molding powder is in the production of clarinets. These instruments have the tonal qualities of clarinets made from the best grade wood and greatly superior to those of metal or rubber. As mentioned in the September 1947 issue of *Modern Plastics,* other advantages include toughness, dimensional stability, low cost and superior water and corrosion resistance. Wood-flour filled and paper-filled materials have been used successfully.

Rubber-like products can be obtained by vulcanizing certain polyester resins. When properly pigmented, these elastomers have strength and elongation properties comparable to other synthetic rubbers. The structure and molecular weight of the polyesters are relatively easy to control and these materials, as indicated in the September 1947 issue of *Industrial and Engineering Chemistry,* are particularly useful in the study of chemical structure vs elastomeric properties.

Uniformity of synthetic rubber is now far superior to that possible with natural rubber, according to some synthetic rubber experts. Improvement in test methods and standardization of procedures during the past five years have contributed to this fine control of man-made rubber. An article in the Sept. 1947 issue of *India Rubber World* reviews current experimental tests that promise still better uniformity for future synthetic rubber materials.

NONFERROUS METALS

Aluminum drums, with 30 gal. capacities, are now being used as shipping containers for chemicals. These drums are constructed of high purity 0.114 in. aluminum sheets. Reinforcing rings are made from high strength R 361 alloy. The total drum weight is only 34 lb compared to 64-70 lb for a steel drum of comparable capacity and strength. These containers have been successfully used to ship materials that would otherwise have to be shipped in glass carboys or glass-lined steel drums. As mentioned in *Modern Metals,* August, 1947, shipping charges, handling expense and breakage is considerably reduced by the use of these aluminum drums.

Magnesium alloy sheet and extrusions are being Heliarc-welded to form combination storm sash and screen units. Another use for magnesium alloy, according to *Modern Metals,* August 1947, is in the manufacture of piano actions where it is used to reduce sticky performance. The individual hammers and the main rail are made of magnesium alloy.

Weight-stiffness factors are further illustrated for combined wood and metal in a staff article in the Oct. 1947 issue of *Modern Metals.* Known as Plymetl, this panel is constructed of two sheets of light gage metal, aluminum or steel, surrounding a plywood plaque. One panel, using aluminum metal sheets, weighs 1.43 lb per sq foot. The weight of 20 gage steel is 1.5 lb per sq foot. The composite panel, lighter in weight, has 100 times the stiffness of the steel panel. The fabricated panel can be sawed with a hand saw, band, circular or jig saw, depending on the type of

metal used for face and back. It can be drilled with an ordinary metal-cutting twist drill. Panels of this material can be fastened into place with nails, bolts, screws or rivets, and can be soldered, brazed or copper arc welded. Surface finishing techniques for these panels are the same as used on the metal sheets in ordinary use.

Strip and sheet steel scarcities have again led automobile producers to consider the use of aluminum alloy sheet in order to meet production schedules. Seam-welded aluminum gas tanks, according to *Iron Age*, Sept. 25, 1947, will be used on Kaiser-Frazer cars. The aluminum tank will weigh 7 lb as against 22 lb for the present steel tanks, and at present production rates this will afford a saving of 8½ tons of steel per day. Ford engineers have estimated that an additional 100,000 cars per year could be produced if 120 lb of steel sheet could be eliminated from the present model. To date they have saved 18 lb by using 0.080 in. aluminum alloy running boards and three pounds by the use of aluminum for steel headlamp housings. Approximately 43 other applications for aluminum alloys on Ford cars are now under consideration. These include: Air cleaner housing, cross members for the radiators, headlamp adjusting rings, name plates and scuff plates for doors. It is estimated that a saving as high as 200 lb per car can eventually be achieved.

Non-ferrous metals, used on marine and allied installations, have been discussed in a series of reviews in the August 29, 1947 issue of *Metal Industries*. As mentioned by E. Voce, such applications are less spectacular than some highly specialized engineering uses but they are constantly faced by a highly corrosive atmosphere. On shipboard, copper is used for degaussing equipment, power distribution and communication systems, as well as for piping used to distribute fresh water, compressed air, steam and oil. For electrical apparatus, where retention of strength at elevated temperatures is desirable, hard drawn copper containing 6.8 percent cadmium has been used. The softening temperature of this alloy has been raised approximately 180 deg Fahrenheit. Hence cadmium alloyed copper is used in windings and for applications involving soldering. A 0.5 chromium copper alloy has been successfully used for cylinder heads on internal combustion engines. The higher thermal conductivities permit greater power output at take-off than otherwise. Tellurium-copper has been used for radar parts; particularly in the magnetron where the good machinability of this high conductivity copper was essential in meeting the prescribed precision tolerances on holes and slots. Tellurium imparted machinability to the copper without the hot-shortness associated with the leaded coppers or the loss in conductivity associated with the addition of small amounts of phosphorus. High strength brasses, phosphor bronzes, gun metal and Admiralty metal are widely used on machine installations. Examples of the widespread use of nickel for marine applications, cited by A. E. Hanson, include nickel bearing bronzes, nickel steels, Monel, stainless steels, copper-nickel and nickel-silver alloys. Aluminum alloys, as mentioned by E. G. West, are used in superstructures, bus bars, fuel tanks for diesel engines, and hatch covers. Aluminum alloys are principally used to reduce dead weight.

Zinc base die-castings have been analyzed to determine the quality of the finished surface. The most common defects found, according to A. W. Sundwick, *Steel*, Sept. 15, 1947 are chills, splashing, gateholes, cold laps, soldering and swirls. Chills are apt to occur when the die or metal temperature is below the optimum operating temperature, when the applied pressure is too low, or when there is a delay in applying the pressure after the cavity is partially filled with metal. These chills may also be due to improper location of gates or vents. Flashing effects, found in heavy sections where chills are not apt to occur, are usually caused by improper gate design. Porosity at the gate opening can be overcome, or substantially reduced, by increasing the pressure on the metal or by changing the runner to decrease any tendency to turbulence. Cold laps have been corrected by opening gates and runners, although in some cases it was necessary to relocate the gate opening. Overflow cavaties have frequently corrected defects occuring near the parting line.

Plating of nickel and cobalt on metal surfaces can be accomplished without the use electricity by a method developed at the National Bureau of Standards by A. Brenner and G. E. Riddell, *Mechanical Engineering*, Sept. 1947. The process, known as electroless plating, is brought about by chemical reduction of a nickel or cobalt salt with hypophosphite in hot solution. This is a catalytic reaction that requires the presence of iron, steel, nickel, gold, palladium or aluminum and careful control of the solution pH. As formed, the electroless nickel deposit is brittle, but becomes ductile on heating. These deposits are harder than the ordinary electrodeposited nickel and become even harder on heating. Cobalt or cobalt-nickel deposits have been obtained, but only from ammoniacal solutions, while nickel has been plated from both acid and alkali solutions. The new process is applicable to the plating of irregular, recessed or inclosed areas where specially shaped and positioned electrodes are needed in electroplating.

Molybdenum, tungsten and chromium, and compounds and alloys of the first two of these metals can be plated by thermal decomposition of their carbonyls. As mentioned by J. J. Lander and L. H. Germer, *Metals Technology*, September 1947, this process is termed pyrolysis. Since neither molybdenum nor tungsten have been successfully electroplated, this technique offers a method of applying thin adherent coatings of these two metals to parts where better abrasion or heat resistance is desired. Improved surface hardness results when the metals are deposited as carbides. Platings having a hardness greater than that of sapphire have been produced by adjusting the carbon content.

IRON AND STEEL

Clad steels, ordinary carbon steels faced on one or both sides with stainless steel, nickel, copper, silver or other corrosion-resisting alloy, are now less expensive than a solid piece of the facing metal. The duplex material has to be handled differently from solid material in some ways. Pickling is done by swabbing rather than immersion so the back side and the cut edges are not attacked. Cut edges are welded together with special techniques and special welding rods. These rods must be designed to compensate for the iron pick-up from the steel backing and yet give a weld with the corrosion resistance of the facing. However, deeper drawing, without annealing, can be performed on stainless-clad than on solid stainless. A discussion of proven and possible uses for clad steels are given in a staff article in the Sept. 1947 issue of *Materials and Methods*.

Embrittling graphitization of carbon molybdenum piping for high pressure, high temperature steam has received much attention in the last four years. According to A. B. Wilder and J. D. Tyson, A.S.M. preprint No. 14, introduction of chromium to stabilize the steel and avoidance of aluminum in killing the steel have been remedies proposed to combat the tendency toward graphitization. Embrittlement, upon aging of cold-worked low carbon steels, and the relative notch toughness of different types of low carbon steels at subzero temperatures are used by A. B. Wilder in *Steel*, Sept. 29, 1947, to

emphasize the differences produced by different methods of deoxidizing or "killing" a heat of steel. These ideas are incidental in a discussion of physical properties of steels now being used to avoid graphitization in high-temperature power plant piping. The mechanical properties and the behavior of these steels, depend on the grain size, aging characteristics, etc., which are controlled by the deoxidation practice. Details of these differences are given by which the designer may make a choice suited to the service demands.

Haphazard tightening of bolts is being replaced by accurate specification of bolt tension, which is checked by strain gages. Flanged joints, gaskets and correct tightness for bolts, all at room temperature, are discussed by S. Labrow in the June 1947 *Journal* of the (British) Institution of Engineers. Formulas for loading and constants for different types of gaskets are listed. It has been found that thread lubrication is essential, and that a thin shellac wash on mating surfaces is advisable. Bolt breakage caused by fatigue can be avoided through the use of vanishing threads. Some of the engineers of this society have indicated that flange joints are obsolete, and should be replaced by welded joints. When flanges are used, the calculations of the engineer can be upset by the way the pipe fitter tightens the bolts; this being responsible for 80 percent of joint failures.

Austenitic malleable iron composition is slightly modified from that of commercial austenitic nickel-copper-chromium cast iron, which is corrosion resistant in some environments, but has about 30,000 psi tensile strength and one percent elongation. By modifying the composition, chill-casting to make the iron white, and malleablizing at 1,800 F for 2 hours, the properties are raised to 70,000 psi tensile strength, 50,000 psi yield strength and about 5 percent elongation. Used for bolts on pipe joints, now, C. K. Donoho, *Materials and Methods*, Sept. 1947, suggests that this cupola-melted metal can be substituted for stainless steel in other uses.

Silicon in cast carbon and carbon-molybdenum steels, normalized and tempered, has minor effects upon room temperature properties As mentioned by N A. Ziegler, W. L. Meinhart and J. R. Goldsmith, Oct. A.S.M. preprint, room temperature properties remained constant even with the silicon content as high as two percent. The notched bar behavior was impaired when more than one percent of silicon was contained in a steel with 0.30 percent carbon. Low carbon steels are less effected by the presence of silicon. About 0.5 percent silicon is used for deoxidation in practically all cast steels. It has been found that these steels can be welded without special precautions when the silicon content is as high as two percent.

Hardenable steels, previously considered not amenable to welding, can be soundly welded by preheating and post heating the material to be welded. Welding rods should be coated with the "lime-ferritic", low hydrogen, type of coating instead of the high hydrogen cellulose-type coatings. Detailed welding instructions are given for 5 Cr ½ Mo by O. T. Barnett in the Sept. 29, 1947 issue of *Steel*. In many applications where austenitic welding rods were specified to avoid cracking, suitable preheating and the low hydrogen rod do just as well. In welding such hardenable steels the weld must not be allowed to cool between the first and the latter passes. However, application of these principles without keeping out hydrogen did not prevent cracking. The introduction of the low-hydrogen electrode "has revolutionized the thinking about the weldability of hardenable steels".

Cast heat-resistant alloys, with the exception of the super-alloys developed for gas turbine and jet propulsion use, are compared by H. S. Avery and C. R. Wilks in an A.S.M. preprint. Very complete discussion is given to the 26 Cr 20 Ni and its properties and behavior compared with those of 26 Cr 12 Ni and 16 Cr 35 Ni. The first is evaluated as giving best performance for all-around service above 1,600 F, the second as more economical and adequate for a greater variety of uses, and the third for use under cyclic temperatures or strongly carburizing conditions. Silicon fortifies the first against carburization, while this addition is not so safely made to the second.

Dimensional stability is an important factor in steels used to make tools and gages. S. G. Fletcher, B. L. Averbach and M. Cohen, A.S.M. preprint No. 7, discussed this characteristic for a 52100 type of steel containing 0.20 percent vanadium, a plain high carbon tool steel and a high carbon, tungsten-molybdenum-vanadium die steel. Expansion on oil-hardening and contraction on tempering primarily govern the final dimensions. In these steels, hardening is incomplete and some austenite is retained. Later transformation of this austenite alters the dimensions and complicates the dimensional problem. Offhand, it would appear that to transform all the austenite to martensite by subcooling to −320 F would be the proper solution. But, unless the refrigeration promptly follows the quench, not all the austenite transformed is stabilized. The degree of stabilization produced when the refrigeration is delayed varies with different steels. The 52100 steel is more easily stabilized than the other two steels studied. The controlling factors and the limit to which they can be controlled, are explained so that the final size of a die and the dimensional stability of a gage can be predetermined.

Retained austenite creates a problem, particularly in case-carburized steel, because its stabilization behavior varies for different types of steel. It has been thought that the retained austenite acts as a cushion to supply greater toughness, to these quite brittle, very hard surfaces. If it is not stabilized and will transform to brittle, untempered martensite under the conditions of use, it is generally considered detrimental. The composition and conditions in which stabilization behavior varies is still incomplete for many carburizing steels. Without entering into the question of whether retained austenite will remain as such in service, S. A. Herres and C. H. Lorig, A.S.M. preprint No. 20, conclude that there is no real evidence that small amounts of retained austenite have any effect on toughness in ordinary steels. It has been found that actual tests on each individual steel sample give better information than calculations.

Boron greatly increases hardenability of the lower carbon steels but does not lower the martensite formation temperature. As pointed out by G. D. Rahrer and C. D. Armstrong, A.S.M. preprint, boron reduces the tendency for steels to crack when quenched. In addition to carbon steels, steels of the 4300, 4600, 8600 and 9400 series as well as other Mn-Cr-Ni-Mo steels have been studied with regard to boron additions. At a given carbon content, the effects of boron were very similar; whatever the rest of the alloy composition. Thus, the desired hardenability is obtained with boron at a lower carbon and alloy level, higher martensite temperature and reduced danger of cracking.

Room temperatures, as mentioned by the same authors in a different paper, are tempering temperatures from the standpoint of gages. Martensite transforms slightly, though not appreciably softened, and retained austenite can also decompose at room temperatures. It is desirable to initially transform all the retained austenite and to temper the martensite at a temperature somewhat higher than that which will be found during gage use. Unstable gages will be produced if these precautions are neglected.

Analysis of MOTOR NOISE

Table I—General Chart Comparing Factors Affecting Motor Noise

Type of Noise	Factor Affecting Motor Noise		With increasing or better factor in adjacent L. H. column, the noise level		References for designing motor, decibels			Approximate silencing effect, decibels
			Increases	Decreases	Quiet 50–60	Silent 40–45	Supersilent 35 and less	
General	Machine construction				Make general construction as rigid as possible. Coat stator lamination core with light metal frame. Subdivide rotor into several electrically independent parts with aluminum bare winding.			
						Inclosed construction		
							Reduction of electrical output by 30 to 35 percent.	
Magnetic	Winding irregularities		x		Symmetrical winding			
	Rotor stator slot number ratio			x	Suitable values of slot numbers			
	Bevel of armature slots			x	Optimum value of bevel, see formula			10–20
Ventilating	Radial air gap			x	Optimum value of gap = 0.15 × fan dia.			10–15
	Fan diameter		x					15–35
	Speed		x					15–30
	Number of blades			x	Odd number of blades			7–10
	Pitch of blades			Equal pitch				
	Blade profile			Streamlined			Aerofoil	9-10
	Duty		x					10–15
	Blow-out grid, or guide vanes			x				6–7
Mechanical	Unbalance	General unbalance	x		Careful dynamic balancing of all rotating parts			
		Type and size of bearing	Bore	Ball dia.	Bearings of small dia. and massive type		Plain bearings	7–11
		Speed	x				Lower speed	10–15
		Lubrication		x			Syphon lubrication; viscous lubricants	7–12
		Mounting and fit		x	Careful control; force fit			10–15
	Brushes and brush holders for commutator machines	Speed	x					
		Machining and pressing of commutator		x			Warm pressing of commutator	
		Specific pressure		x	Good pressure of brushes			13–15
		Hardness	x				Soft brushes	
		Adjustment of brush holders		x	Good adjustment of brush holders			

AND HOW IT CAN BE MINIMIZED

WILLIAM O. ORDINANZ
Mechanical Engineer, Brasov, Rumania

A European engineer analyzes the fundamental electrical and mechanical causes of motor noise and offers remedial measures. Windings, optimum slot ratios, speed, fan diameter, clearance and duty, type and size of bearings, mountings and fits are included.

QUIET MOTORS are increasingly important for the satisfactory performance of many industrial, commercial, and domestic designs. For example, refrigerating and air conditioning units, domestic water circulating pumps, and theatre ventilating systems are typical applications that require relatively silent motors.

The frequency-analyzer shows that motor noise is a complex of sounds composed of: (1) Magnetic noises, produced by the motor's magnetic fields; (2) ventilating noises, produced by the fan; and (3) mechanical noises caused by bearings, brushes, and other mechanical parts. A chart showing the factors that usually influence motor noise is shown in Table I. In general, the ventilating noise is preponderant and produces the background of the noise complex on which the magnetic noise is superposed, and the mechanical noises form the different peaks in single frequencies. A typical noise oscillogram is shown in Fig. 1 for a motor generator.

A survey of published data shows that ordinary motors produce a noise level in the range of 65 to 100 decibels, or db., and such motors are usually too noisy for use in areas with noise levels less than 65 db. To help designers alleviate noise where needed, three general classes of motors are considered: (1) Quiet motors with 50-60 db.; (2) silent, or noise free, motors with 40-45 db; and (3) supersilent, or noiseless, motors with less than 35 db. These groups are shown in Fig. 2 in relation to typical surroundings in which they operate.

When a motor produces a certain noise level in a room with a different noise level, the human ear always per-

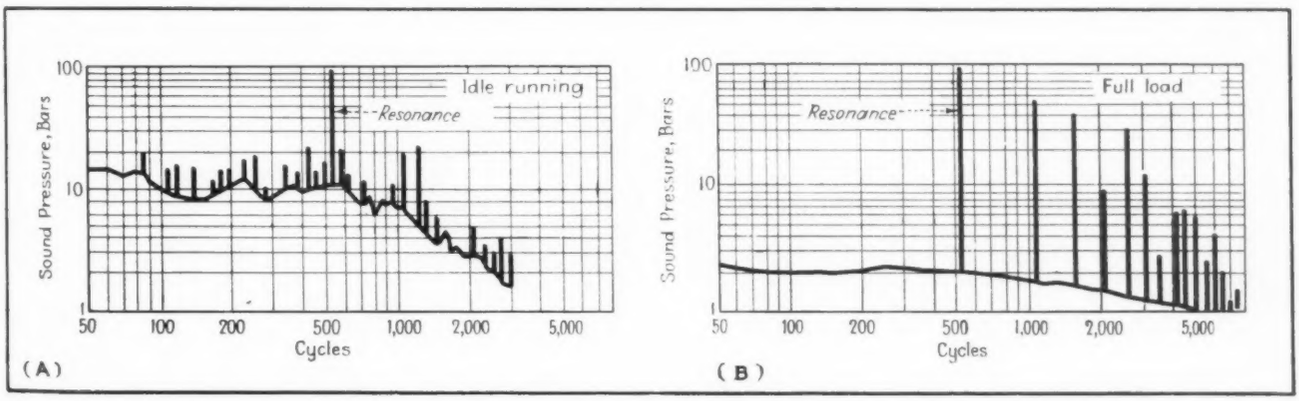


Fig. 1—Noise oscillogram of this motor generator shows machine resonance of 530 cycles. (A) At no-load, noise is 89 decibels, (B) at full load, noise increases to 99 decibels. Spectrum of magnetic, ventilating, and mechanical noise.

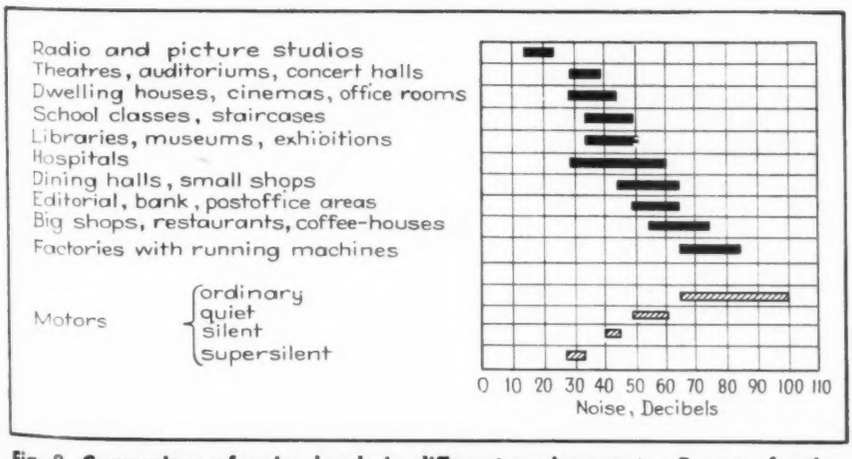


Fig. 2—Comparison of noise levels in different environments. Range of noise for ordinary, quiet, silent and supersilent motors is at bottom of the chart.

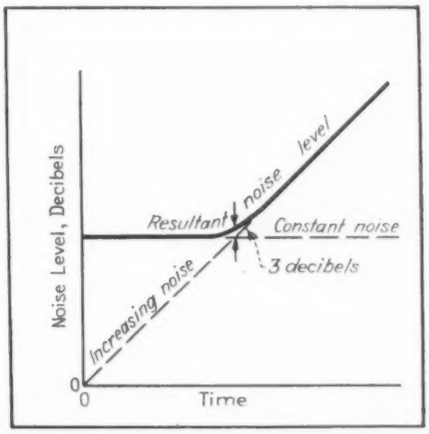


Fig. 3—With two noises the ear always perceives the more intensive noise.

ceives the more intensive one. If both are of equal intensity, the perceived noise level is about 3 db. higher than the single noise, Fig. 3, provided the two noises are approximately equal in their frequency composition. For two noises of widely differing frequency composition, the perceived noise level can be up to 10 db. higher than the single noise. In practice, the frequency composition of the preponderant noises in industry and the home is such that the motor noise can be 5 db. above the noise level of the respective room.

Analyzing Noisy Motor

In analyzing noise, the frequency-analyser sorts out the different single frequency components that form the composite noise pattern. The instrument gives both qualitative and quantitive measurements of noises and sounds. Frequency-analyzers use a microphone, amplifier, sound-testing generator for adjusting certain frequencies, and an output meter. If the adjusted frequency is present in the noise being examinated, the output-meter gives the value of sound-pressure for that frequency, and successively adjusting all frequencies on the sound-testing generator, gives the complete composition of the noise.

When analyzing frequencies of noise in motors, where m is the rpm, K the number of fan blades, S the number of rotor slots, and C the number of commutator bars, then the base frequency of the different noises in cycles is

$$\text{ventilator noise, } f_v = \frac{m \times K}{60}$$

$$\text{magnetic noise, } f_m = \frac{m \times S}{60}$$

$$\text{brush noise, } f_b = \frac{m \times C}{60}$$

To each base-frequency the supersonic higher harmonics such as the double and triple frequency are added. The ball bearing noise has its frequencies in the diapason of 1,000 to 6,000 cycles, or, in the range of greatest audibility without any dependance on speed.

In noise investigation, undesired resonance oscillations are eliminated by free suspension of the tested motor. Penetration of undesired noises and the interference of reflected sound waves of the noise itself from the walls also are prevented. One design of a small special cabinet used for noise investigation is the small silence-cabinet shown in Fig. 4. The walls of 5/8 in. boards with a 3/8 in. layer of rubber provide sound-deadening effect of 85 to 105 db., and thus practically elminates all of the extraneous noises. The inner walls have a 2 in. thick wadding-layer that practically absorbs the whole sound and prevents its reflection. The microphone is freely suspended, and the motor is mounted on an elastic support and connected by a flexible coupling with a motor outside the cabinet. The driving shaft passes through the wall in a rubber sleeve, in order not to impair or nullify the isolating effect of the walls by fissures. The outside motor drives or loads the motor mounted on the inside.

Table II—Advantageous Ratios of Stator and Rotor Slots for Low Magnetic Noise in Motors

Pairs Poles, p	Stator Slots, z_1	Number of Slots in Rotor, z_2
		Non-bevelled slots
2	24	18 30
	36	30 42 46
	48	38 42 54 58
3	36	32 34 38 40 44 46
	54	34 46 50 52 56 58 62 64 68
	72	58 62 64 68 70 74
		Bevelled slots
1	24	16 22 28
	36	16 24 28 48
	48	40 52
	60	48
2	36	24 30 40 42 44 60
	48	44 56 60 84
	60	44 48 72 84
3	36	30 42 48 54
	54	48 72 88
	72	54 84 90 96
4	36	48
	48	60 72
	72	84 96

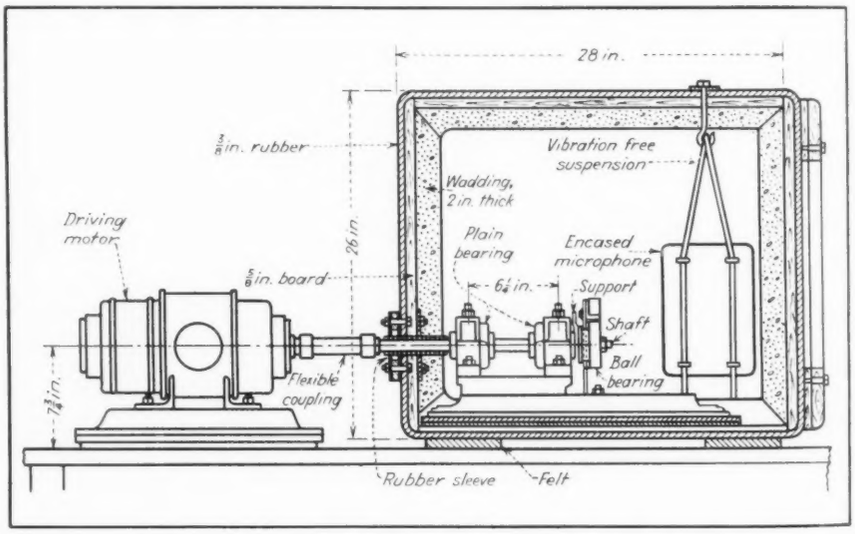


Fig. 4—Typical inclosure that is suitable for making motor noise investigations. A thick layer of wadding inside and rubber outside help provide sound deadening.

Magnetic Noises

The magnetic fields produce elastic deformations in the motor resulting in vibrations of the non-rigid machine-

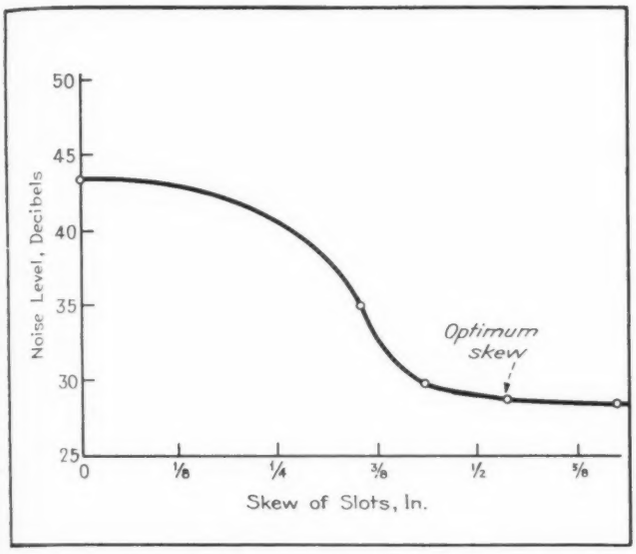


Fig. 5—The degree of skew substantially affects the noise level of an ordinary motor. Optimum skew is about ½ inch.

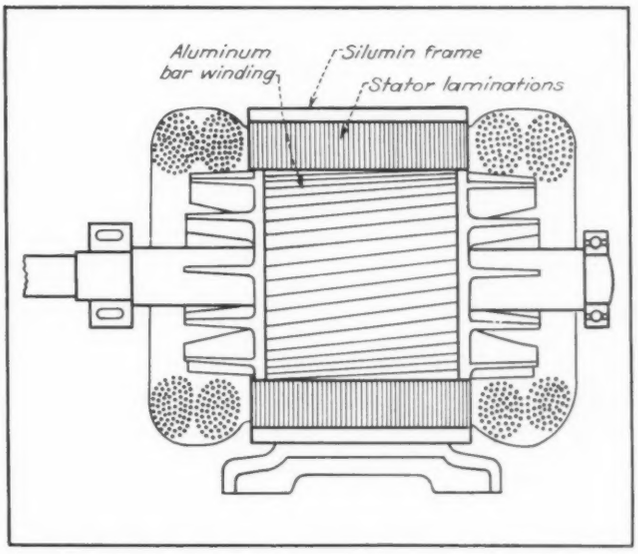


Fig. 6—For rigidity the laminated stator core has a silumin frame and cast aluminum bar winding in rotor slots.

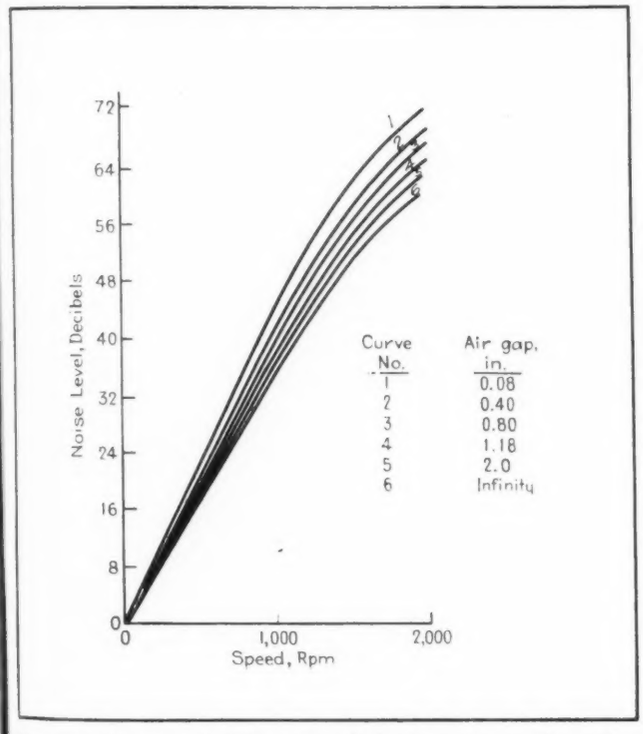


Fig. 7—Influence of different radial air gaps on the noise level of a fan with 11⅝ in. wheel diameter and 12 blades.

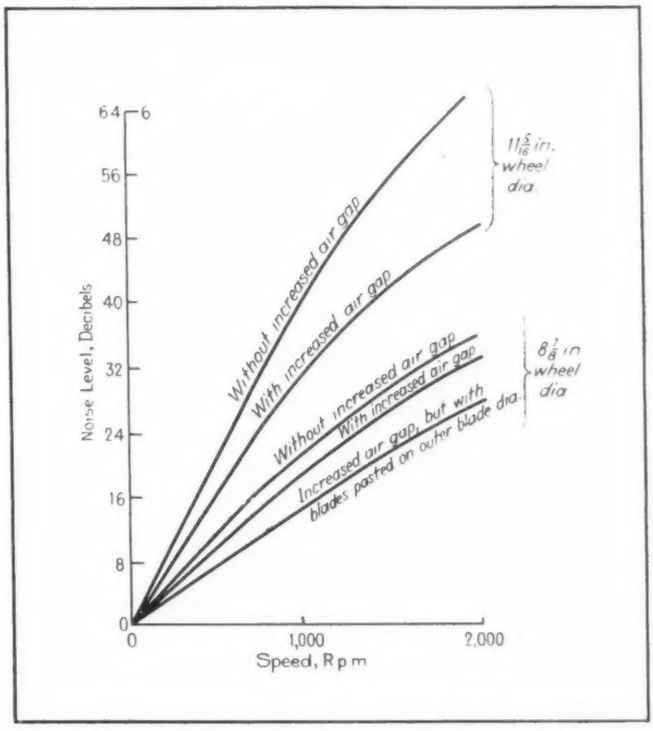


Fig. 8—Influence of fan diameter and air gap on noise level. Noise level increases with change in the diameter of fan.

parts. The sound vibrations are intensified by transmission to the other parts of the machine and appear as noise. Rigid construction is extremely important because of the minute energy required for the production of noise. For instance, 1.10^{-8} watts can vibrate 1 sq. in. of motor case surface with 0.05 in. amplitude at 1,000 cycles. For comparison, the sound energy of a cannon being shot is about 1 watt, based on a noise on the threshhold of audibility in the range of 1.10^{-12} watts. Hence, motor rigidity.

In investigating magnetic noise the fan is removed and the ball or roller bearings are replaced by noiseless plain bearings. In commutator motors, the brush holders are accurately adjusted and soft brushes help to minimize brush noises. The outside motor serves as load.

Particular intensification of the magnetic noise arises from: (1) Little irregularities in the winding or machining of the motor that exercise one-sided forces, similar to the mechanical forces a non-balanced machine produces; (2) unfavorable ratio of the numbers of slots in rotor and stator; and (3) none or too little bevelling of the slots.

Desirable ratios for non-bevelled and bevelled slots for low magnetic noise are given in Table II Where p = number of pairs of poles, z_1 = number of slots of stator, z_2 = number of slots of rotor, b = skew of slots in inches, and D_r = diameter of rotor

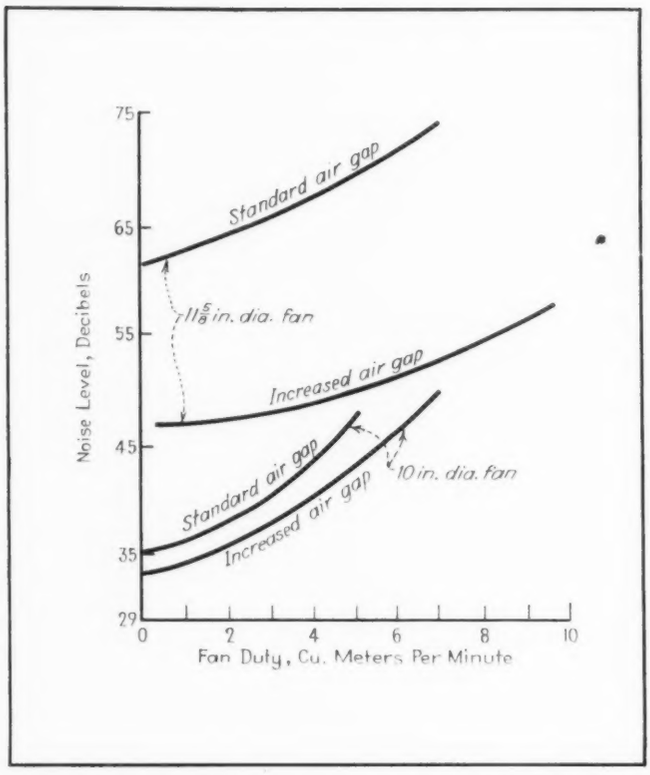


Fig. 9—Effect of fan diameter and duty cycle on noise level for motors having different air gap conditions during test.

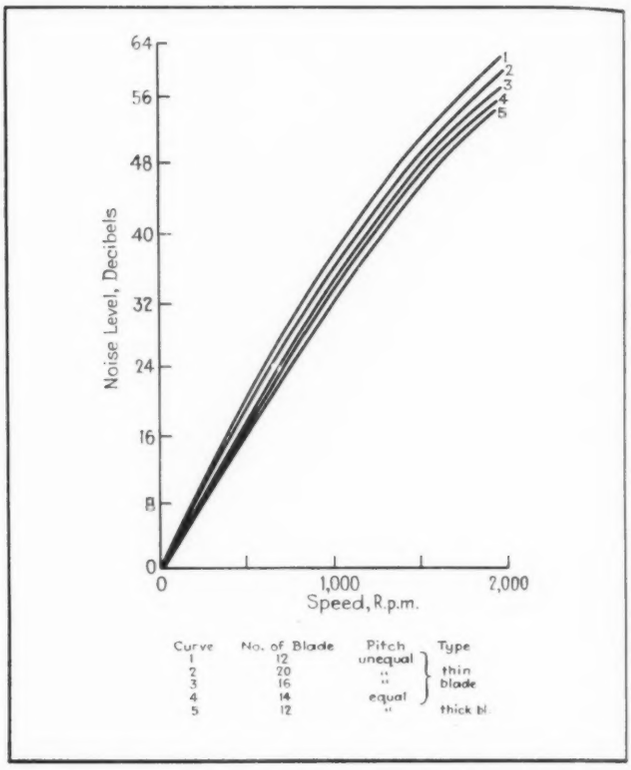


Fig. 10—Comparison of different numbers and types of fan blades in terms of noise level, as shown by test.

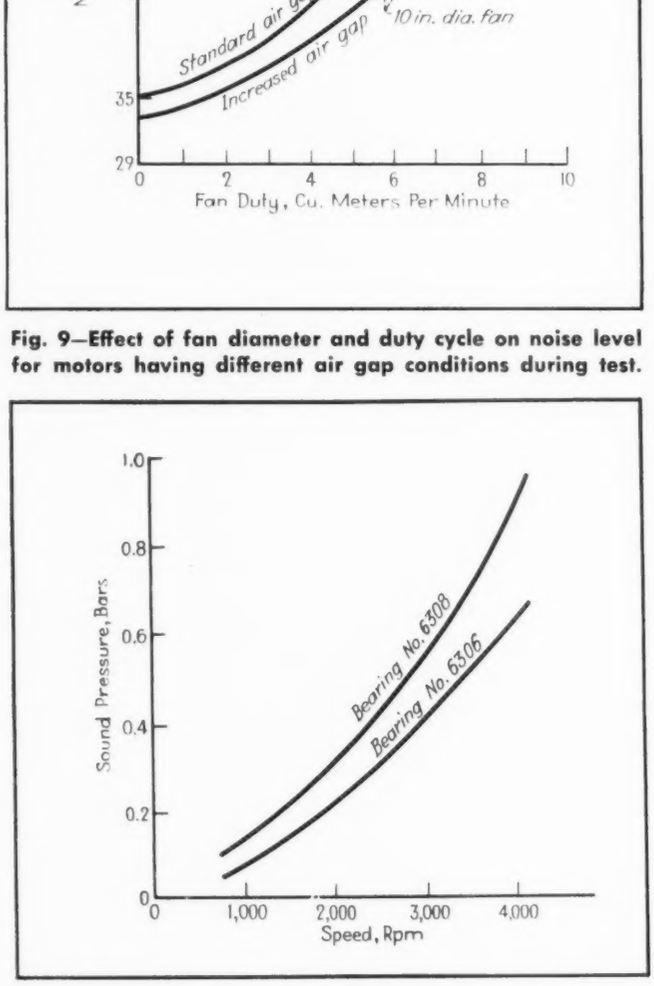


Fig. 11—Influence of speed on noise level of ball bearings. As speed of motor increases the noise level also increases.

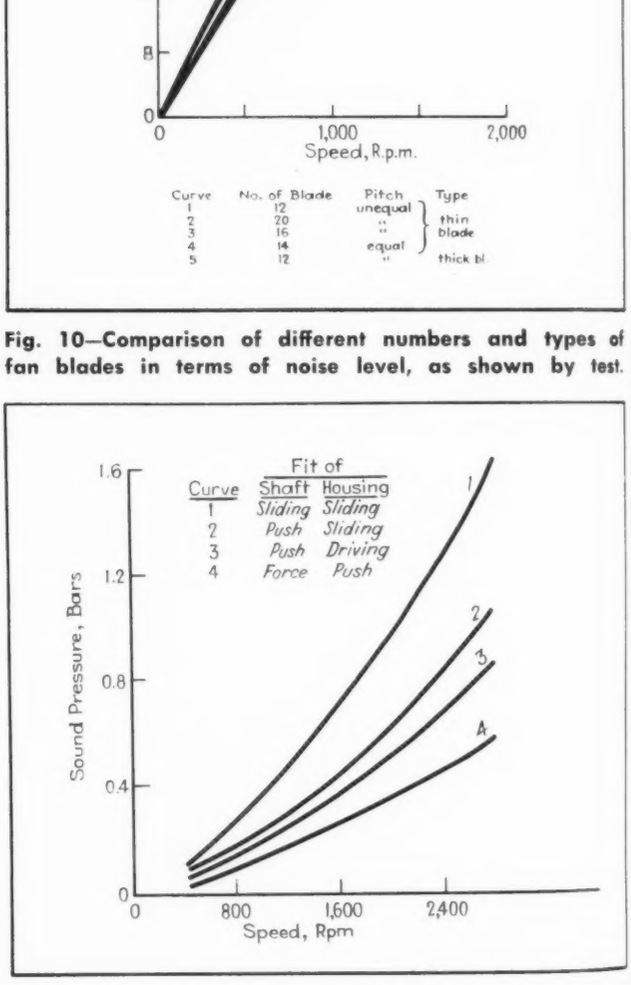


Fig. 12—Comparison of noise level for ball bearings with a constant load of 220 lb, but for different kinds of fits.

in inches, then the most advantageous bevel is

$$b = \frac{D_r}{z_1 + p}$$

The noise level of an ordinary 1,500 rpm induction motor as a function of the skew of slots is plotted in Fig. 5 and shows the optimum skew for a rotor of constant dimensions.

In addition to the design of the winding, magnetic noise can be reduced by: Dividing the length of the rotor into several electrically independent parts; placing a silumin-cast case around the stator laminations as shown in Fig. 6 that combines rigidity with the prevention of undesired magnetic fields; aluminum bar winding cast in rotor slots to avoid irregularities of coil winding; inclosed motors to reduce noise emission; and finally, in supersilent motors the electrical output of the motor is reduced by 30 to 35 percent of its normal magnetic and electrical rating.

Ventilation Noise

The ventilating noise of motors is more intensive than the magnetic and mechanical noises. It is produced by the turbulence in the air flow from the

fan, and varies with the design of fan and the speed of air flow. Factors influencing ventilating noise include: (1) Size of radial air gap between fan and casing, (2) diameter of fan, (3) speed, (4) number and pitch of blades, (5) section or profile of blades, (6) duty or volume flow, and (7) form of blowoff or diffusing grid.

Tests show the following relationships. The ventilator noise increases with diminution of the air gap, Fig. 7, and an optimum value is $0.15 \times$ fan diameter. Noise level increases with the diameter of fan, the duty, and the speed, as shown in Figs. 8 and 9. Fans with more blades give lower noise level, Fig. 10; numbers of blades with equal pitch reduce noise level, the aero-foil section is the best blade profile, and the influence of the form of blow-off grids is negligible.

Mechanical Noise

Mechanical noises are produced by: (1) Non-balanced rotating parts creating centrifugal forces that vibrate non-rigid parts; (2) the anti-friction bearings in which balls and rollers knock on the cage, and the inner raceways during the running; and (3) on commutator motors, by the brushes knocking on the commutator and the walls of the brush-holders.

The first source of noise, as listed, can be removed by carefully balancing the rotating parts of the machine, and providing sufficient rigidity in the construction of the motor.

Investigation of the ball bearing noise requires testing in a sound laboratory or cabinet such as shown in Fig. 4. A shaft supported in two noiseless plain bearings is driven by the outside motor. The inner ring of the ball bearing to be tested is mounted on the end of the shaft, whereas the outer ring is fixed on a support. By means of this device, investigations of the noise level have been made on the basis of the type and size of bearings, number of revolutions, lubrication and mounting fit for single row, radial ball bearings of the light type, and medium type and the magneto series. The results are summarized as follows.

In the test results shown in Table III, the rpm, load, and lubrications were uniform for all bearings. As shown, the influence of the type and size of the bearings upon the noise level is considerable. The noise level increases with the bore nearly in a straight line, and decreases with the ball diameter. In consequence, the larger the size of a bearing, the higher will be the noise level, but the more massive the type of bearing, the lower will be the noise level.

The influence of the speed upon the noise level is shown in Fig. 11. Where P is the sound pressure in dynes per sq.cm., n is rpm, and a and b are two constants depending on the type of bearing, sound pressure can be expressed by the empirical formula $P = a \times n^b$.

The influence of lubrication upon the noise level is substantial as shown by comparing the figures in items 1 through 6 with item 7 in Table IV. These tests were made on a medium size bearing with 19/32 in. balls at 1,500 rpm with siphon lubrication.

The influence of ball bearing fits and tolerances on noise level is important. The tighter the fits, the lower the noise. The curves shown in Fig. 12 give the relation between the number of revolutions, mounting fit, and noise level. The fits refer to the mounting of the inner ring in the support. The micron tolerances are those of ISA standards for medium shaft diameters to 30 to 35 mm and the corresponding outside diameters of 80 to 120 mm.

In general, for a given bearing and good lubrication the noise level depends not only on the speed, but especially on the mounting fit. Wear or seizing of the bearing, a worn out journal, and the like cause a steep increase of the noise. The influence of the load could not be determined.

On commutator motor the brushes generally add to the noise. The noise level produced by brushes increases with the degree of machining of the outer surface of commutator, the degree of pressure of the brushes, and the tight fitting of the brushes in the brush holder.

The kind of current has little influence on motor noise, except as it requires specific design elements.

While American findings may differ in detail and degree, the foregoing analysis stresses that the search for quieter machines is a continuing universal engineering effort.

Table III—Noise Test on Different Size Ball Bearings With Uniform Speed, Load, and Lubrication

Bearing No.	Dimensions, mm Bore,	Dia.	Width	Ball Dia., in.	Noise Level, db.
6305	25	62	17	11/32	54
6306	30	72	19	15/32	59
6307	35	80	21	17/32	61
6308	40	90	23	19/32	63
6310	50	110	27	23/32	67
6200	10	30	9	7/32	56
6202	15	35	11	0.210	56
6204	20	47	14	5/16	59
6206	30	62	16	11/32	62
6012	12	32	7	3/16	53
6015	15	35	8	7/32	58
6017	17	44	11	1/4	61

Table IV—Comparison of Noise Level of Ball Bearing With Different Lubricants and Without Lubrication

No.	Lubricant	Noise Level, db
1	Castor oil	57
2	Viscous machine oil	57
3	Hard grease, technical	58
4	Vaseline, chemically pure	58
5	Transformer oil	60
6	Fluid machine oil	62
7	With no lubrication	70

Typical Trolley Conveyor System

TAKE-UPS. Take-ups are not necessary when there is a definite down run following a drive unit, but should be used in level conveyor systems. It is often necessary to put an extra loop in the system so that the take-up can use a 180 degree turn. Conveyors operating through ovens should have automatic take-ups. Short systems use spring type, and long conveyors are built with counterweighted take-ups for larger differential movement.

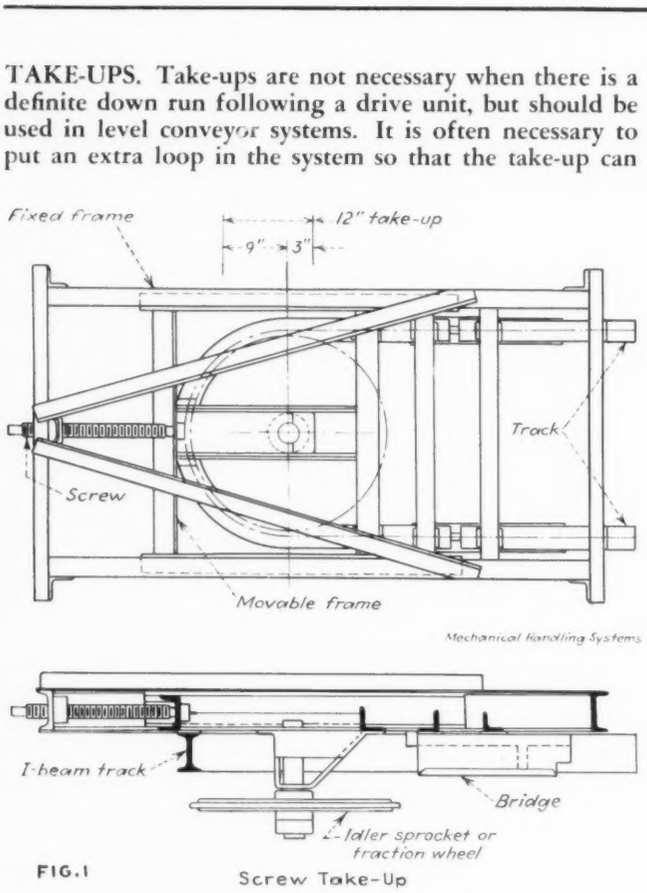


FIG.1 Screw Take-Up
(Also made with roller turns)

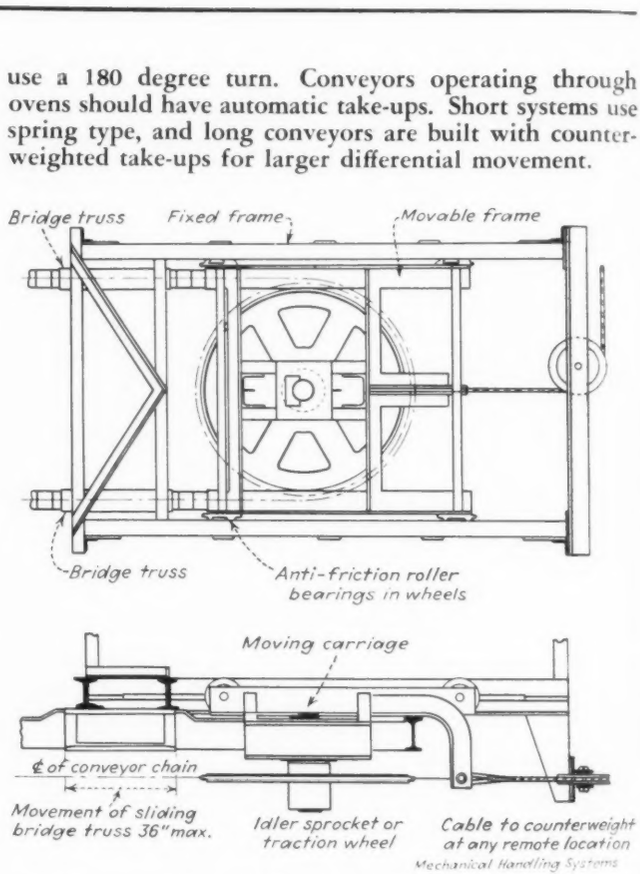


FIG.2 Automatic Counterweight Take-up
Also made with Roller Turns

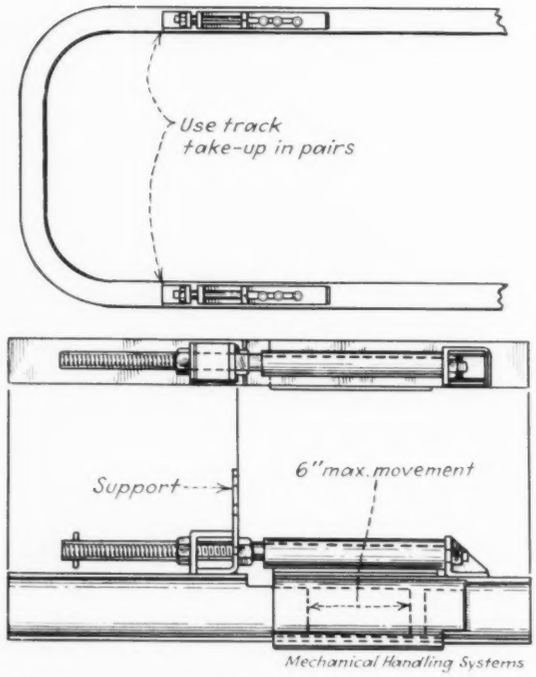


FIG.3 Track Take-Ups

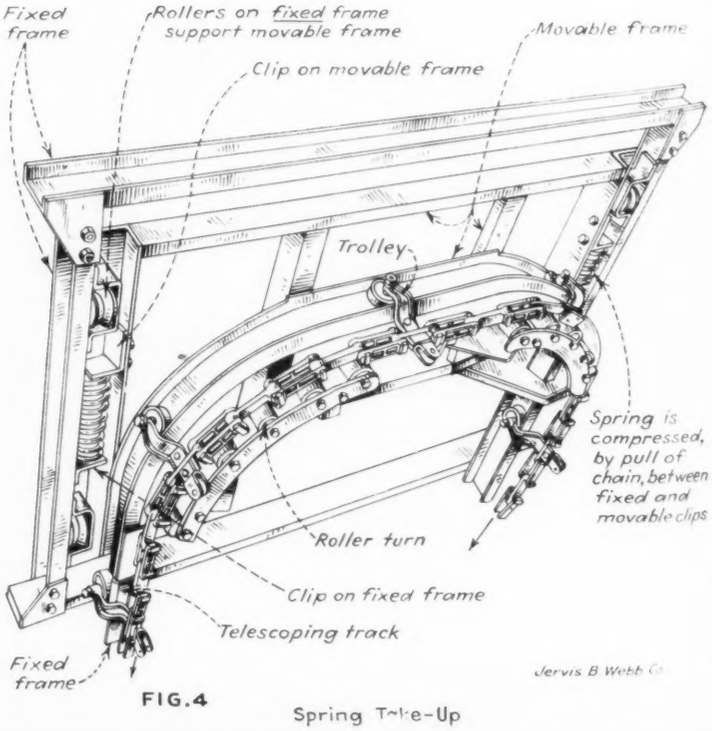


FIG.4 Spring Take-Up

Components

SIDNEY REIBEL
Materials Handling Consultant,
Albert Kahn Associated Architects and Engineers

CHAIN ATTACHMENTS. The drop forged, rivetless Keystone chain is very flexible in use; not only because of its design, but also because of its application possibilities. Light objects can be carried by pin attachments and heavy objects can be transported on trolley attachments. Typical pin and trolley attachments are shown below. Attachments for special applications can be designed for each installation.

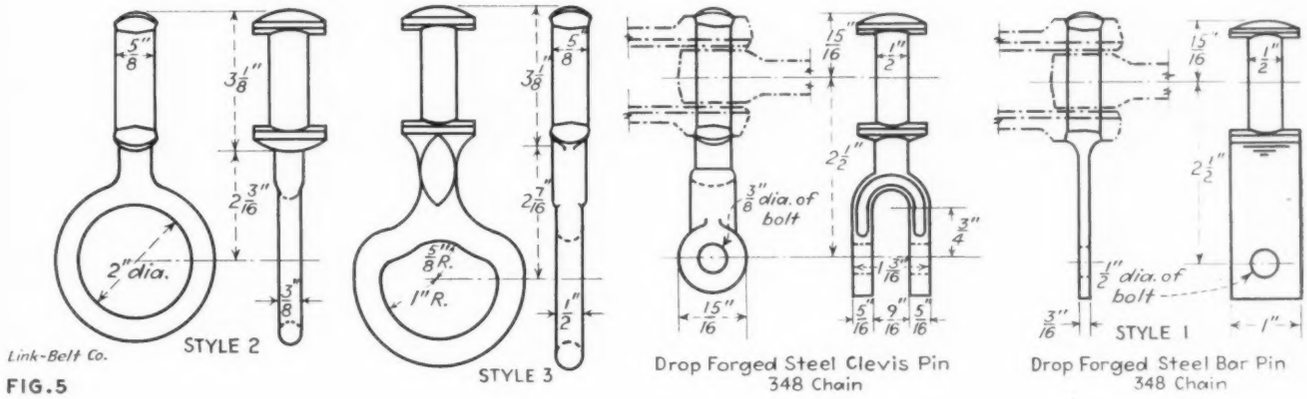


FIG. 5

Drop Forged Steel Clevis Pin
348 Chain

Drop Forged Steel Bar Pin
348 Chain

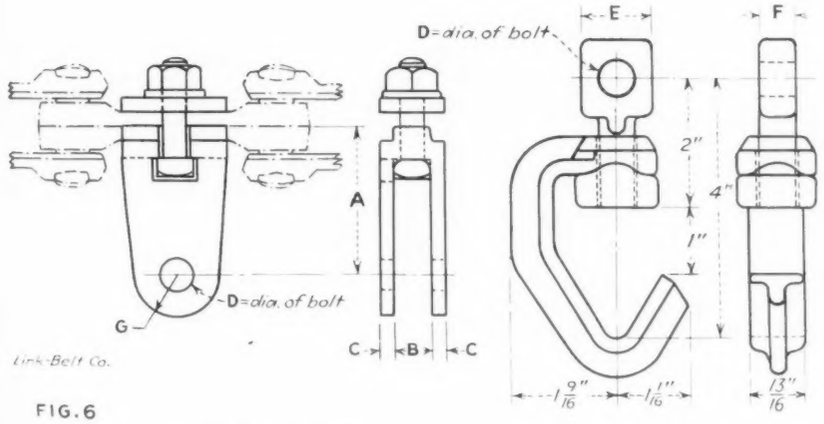


FIG. 6

Malleable Iron
Intermediate Clevis Attachment

Malleable Iron
Swivel Hook

CHAIN NUMBER	DIMENSIONS, IN.						
	A	B	C	D	E	F	G
348	$2\frac{1}{2}$	$\frac{9}{16}$	$\frac{13}{16}$	$\frac{1}{2}$	1	$\frac{17}{32}$	$\frac{5}{8}$
458	$2\frac{7}{8}$	$\frac{11}{16}$	$\frac{1}{4}$	$\frac{1}{2}$	1	$\frac{17}{32}$	$\frac{5}{8}$
678	$3\frac{5}{8}$	$\frac{13}{16}$	$\frac{5}{16}$	$\frac{3}{4}$	$1\frac{1}{2}$	$\frac{5}{8}$	$\frac{7}{8}$

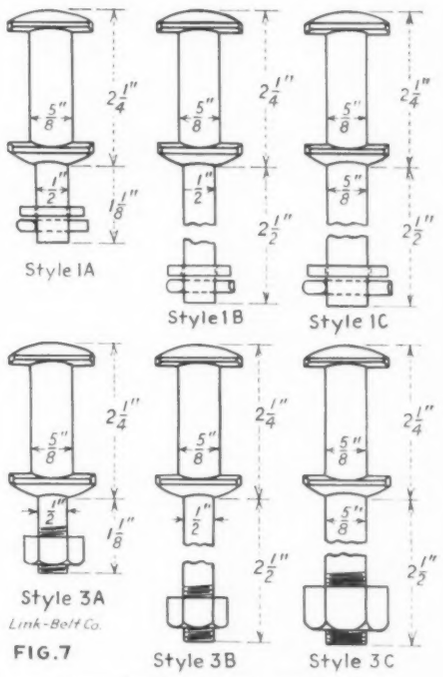


FIG. 7

Drop Forged Steel Extended Pins
458 Chain

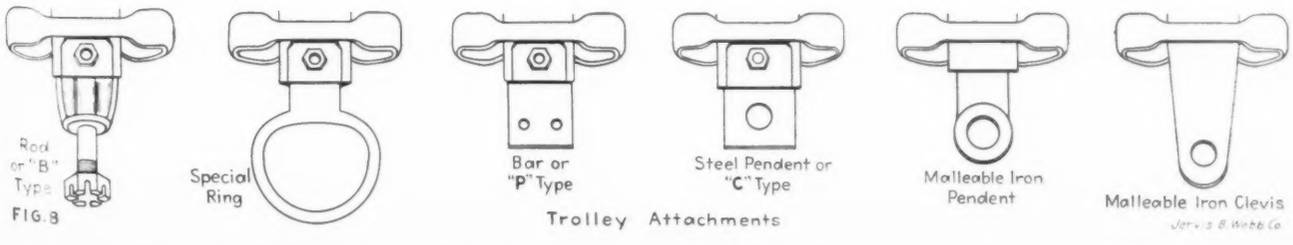
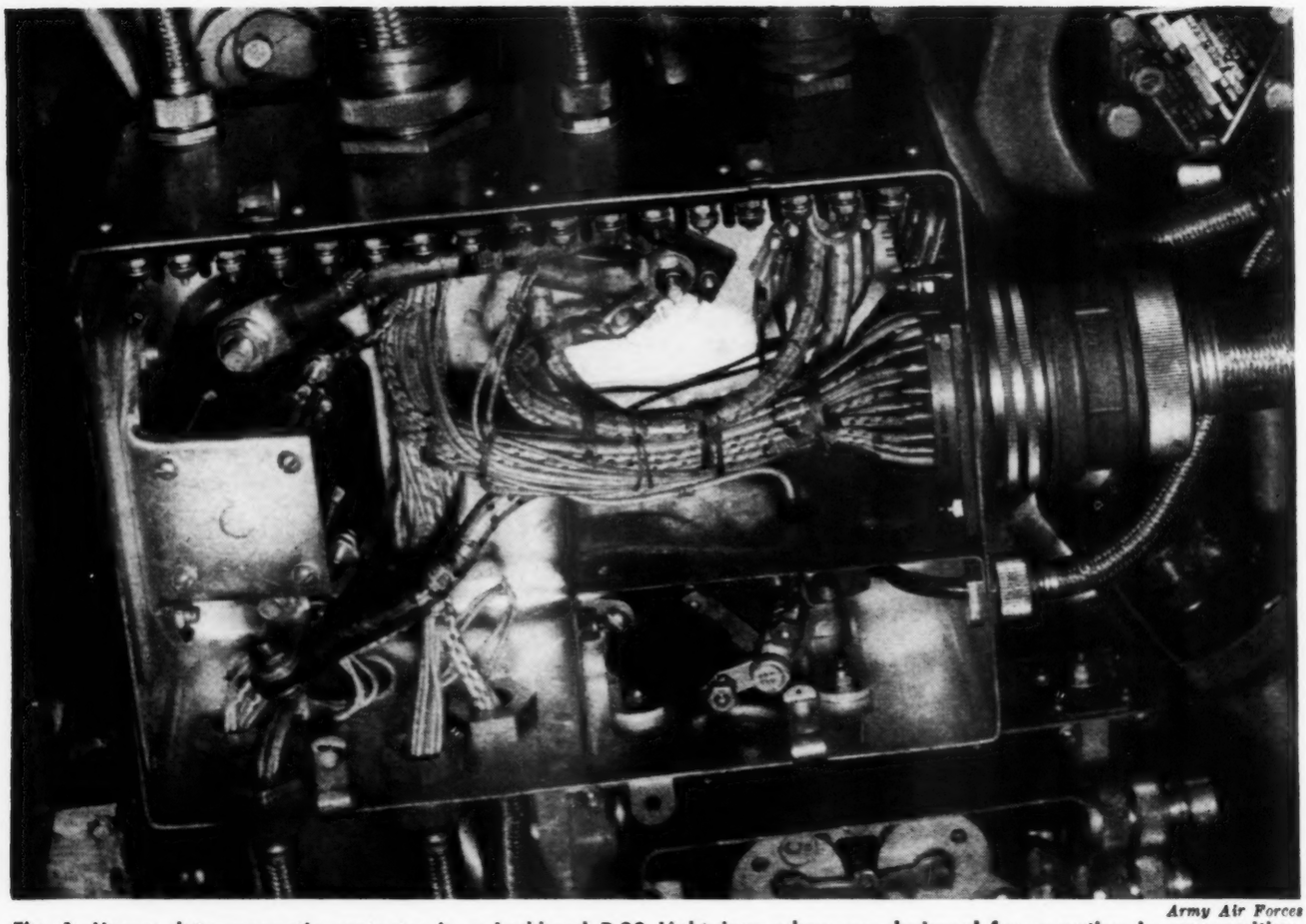


FIG. 8

Trolley Attachments



Army Air Forces

Fig. 1—Heavy duty magnetic contactor in a Lockheed P-38 Lightning; relays are designed for mounting in any position.

Relay Design for Compactness

T. B. HOLLIDAY*
President, Mueller Accessories, Inc.

THE purpose of designing compact relays for aircraft to save weight.

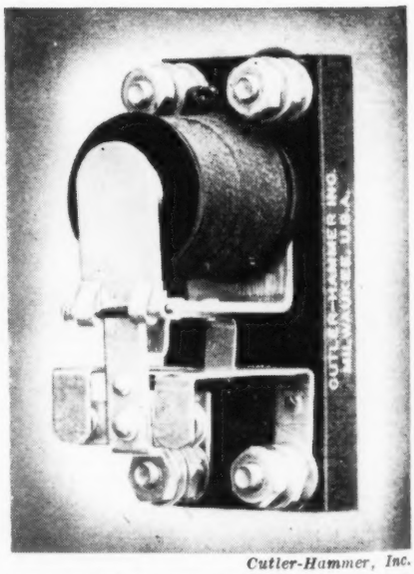
Relays can be divided into two classes—power relays and circuit relays. A power relay, or magnetic contactor, reduces the amount of heavy wiring. A relatively lightweight control circuit actuates the power relay to control a heavy power circuit at a remote point. This saves both the weight of heavy wiring and also voltage loss caused by high current flowing through a long line. The circuit relay uses one circuit through the relay to control many circuits. This saves weight, reduces length of conductor circuits.

Operating experience has proved that successful relay designs for aircraft use must meet diverse requirements. These requirements can be grouped as: (1) Mechanical, (2) electrical, and (3) environmental.

Mechanical requirements include: Position, vibration, acceleration, arrangement, connections, weight, simplicity, special tools, interlocking devices, mounting, size.

Electrical requirements include: Low hold-in voltage, low coil current, special timing needs, insulation and life of electrical creepage, contacts, and coils.

Environmental requirements have steadily increased in scope and include: Altitude, at least to 50,000 feet (two pounds per square inch absolute pressure), temperature to 250 deg. F. and —65 deg. F., moisture, fungus, salt,



Cutler-Hammer, Inc.

Fig. 2—Relay uses balanced armature to reduce vibrational effects on unit.

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sand, dust, rain, sunshine and the like.

Many ingenious solutions have been developed for these requirements.

Mechanical

In the mechanical group, attempts to reduce vibration and acceleration resulted in relays using balanced armatures as shown in Fig. 2. Most relays are designed for acceleration of 10 to 60 cycles per second with an amplitude of 1/16 in., or approximately 12 g. In addition, to determine resistance to acceleration the relays are tested to values as high as 25 g. Pressure between contacts must be adequate to avoid separation under these conditions and yet there must be no bounce of contacts when the circuit is closed. The armature must have sufficient stiffness to avoid resonance and opening of the circuit. The vibration range of 10 to 60 cycles is inadequate, and the effect of frequencies as high as 3,000 cycles per second are being studied.

Weight and size must be kept at a minimum but at the same time standardized arrangement, mounting and space are required. This is done by requiring certain mounting provisions and limiting the maximum dimensions. The aircraft designer must then provide space for these maximum dimensions. Most relay designs are well within some, or all, of these dimensional limits. A relay must be designed for mounting in any position because of space limitations within an aircraft, and operate reliably. Since it is not possible to design for a position so that dust or metal particles will not lodge between contacts, proper functioning of all component parts of the relay must be assured by good designing. For example, many clever arrangements are used to wipe contacts as the circuit is closed.

The Air Forces has encouraged the development of sealed designs that preclude any attempt at maintenance of the relay. This avoids maintenance and malfunctioning. It is based on the experience that a sealed design has sufficient improvement in performance and life that maintenance is not required during life of the aircraft. Although not hermetically sealed, even the amount of sealing shown in Fig. 3 eliminates many causes of troubles that might otherwise occur.

Electrical

Electrical problems of the designer are numerous. Increasing altitude combined with increase in system voltage has revealed severe contact design problems. The ionizing potential for most contact metals is less than the 28 volts used in most aircraft electrical systems. This means that an arc tends to hang on when a relay is opened. To defeat this ionization potential, a bridge type of contactor places two arcs in series as shown in Fig. 4. As altitude increases, the contact area of the arc increases. At 50,000 feet, breakdown voltage is approximately one-fourth to one-third of that at sea level and surface leakage voltages are twenty-five to forty percent of sea level values.

Special timing elements use series resistance, inductances, parallel capacitors, pneumatic and hydraulic dash pots, and other mechanical means. Designers solving special problems of this type must insure performance at the extremes in temperature and altitude.

The aircraft electrical engineer has sacrificed relay life in order to achieve a miniumum of weight and space. Often life of 50,000 cycles is accepted, as compared to 30,000,000 cycles for many industrial relays.

Contact materials for relays should have low specific resistance, should be non-oxidizing, have high thermal conductivity, and melting point with considerable hardness and toughness. For heavy duty magnetic contactors, no single material has all of these desirable contact properties. Therefore, hard, tough arcing contacts operate in parallel with contact of low resistance material that carry current during continuous operation.

The relay coil should have low pull-in voltage and low drop-out voltage at high current, because the power of aircraft electrical systems is limited. Ordinarily, the relay is placed near the controlled device and suffers from the voltage drop from the power source to the device. Thus when the relay is handling its greatest current the coil voltage is the lowest. If the coil voltage is so low that the relay opens, the severe arc will damage the contacts. A series coil would avoid

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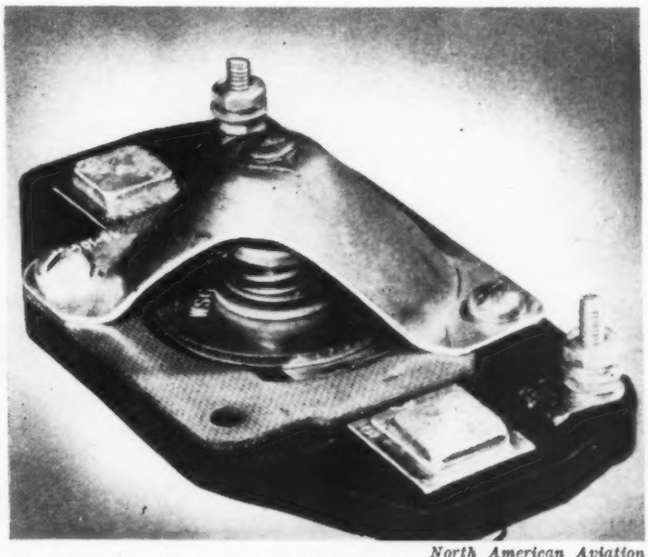
Fig. 3—Molded phenolic housing effectively seals relay contacts to avoid many common relay troubles in service.



North American Aviation

Fig. 4—Solenoid contactor with bridging contact disk. Low voltage drop-out of relay is adjusted by changing airgap.

this danger, but in most aircraft designs it is difficult to balance the ampere turns as satisfactorily as by a voltage coil. The relay shown in Fig. 4 has an adjustable low voltage drop out value that is adjusted by changing the air gap of the magnet. This is not the best method because inevitably the air gap is set too close and improper operation results.

Environmental

The environmental group of requirements include design problems that relays face in no other industry. For example, the temperature limits of −65 deg. to +250 deg. F. seriously restrict the types of plastics that can be used in relays. A plastic that can survive in low temperatures without becoming brittle is quite likely to lose its shape at the high temperatures. Close clearances between metals, and between metals and plastics, can also cause trouble. The aircraft electrical designer uses aluminum to reduce weight but must watch its temperature expansion, since it is much different than that for iron used in magnetic circuits. Thorough testing is the only final answer.

Environmental humidity will approach 95 to 100 percent in temperatures of 100 to 130 deg. F. Steel parts and electric coils must be carefully protected and treated against corrosion. Most of the coils use small conductors and are especially vulnerable to corrosion. The salt spray test is extremely difficult to withstand. Sealed construction with adequate corrosion treatment of external surfaces is the best design answer. Fungicides are needed to protect relays only if internal parts are exposed.

Quality must be maintained in aircraft relays because so many other factors contributing to reliability are sacrificed to obtain minimum weight and space. Complete engineering is vital. Also, tests must be adequate, severe and complete. Production must be carefully supervised. Inspection must be strict. Finally, the relay designer and the aircraft electrical designer must cooperate to make certain that the relay fits the application.

An aircraft relay should not need maintenance. Too often a relay is considered a minor part of the aircraft electrical system and, therefore, would probably not need maintenance. Most of the instructions that relay manufacturers include with industrial relays cannot apply to aircraft relays. For example, instructions that include caution to make sure that covers are in place, that there are no loose parts, and no accumulated dust, should be avoided by producing a design in which these are not a problem. Instructions that include alignment of the contacts and cleaning of the contacts should be avoided by a design in which the contacts cannot be touched. Moving parts that can work loose, catch dust or be rendered ineffective by a defective bearing should be of sealed construction and so designed that a mulfunction cannot occur. The only maintenance that should be needed with an aircraft relay is checking of electrical connections to its terminals.

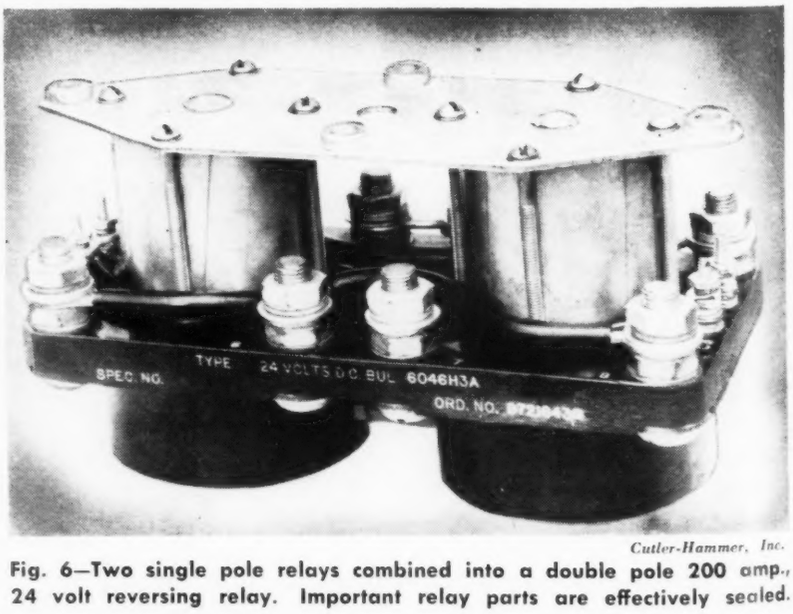
Two successful designs of relays are shown by Figs. 5 and 6. Important parts are effectively sealed but these relays are not environment free. Some designers have gone a step further and have sealed relays into radio tube envelopes and bases. This construction shows great promise since ideal operating conditions surround working parts of the relay at all times. Use of the tube base facilitates installation and checking. The construction is well suited for low power multi-circuit relays and is being extended.

A graphic idea of the maintenance problem is given by Fig. 7 that shows four relays in a box of a North American B-25 Mitchell airplane. The large unit at upper left is the generator reverse current relay and it will receive more attention than all other relays combined. The open design relay below the generator relay is probably in the landing light circuit. This construction is vulnerable to dust and corrosion and is being superseded rapidly. The other two designs are similar to that shown by Fig. 5, with important parts sealed.

An extension of relay utility is obtained by the addition of circuit breaker performance. Typical remotely controlled units are shown by Fig. 8, and they greatly simplify the problem of protecting circuits in distant parts of the airplane. The alternative had been use of a local fuse

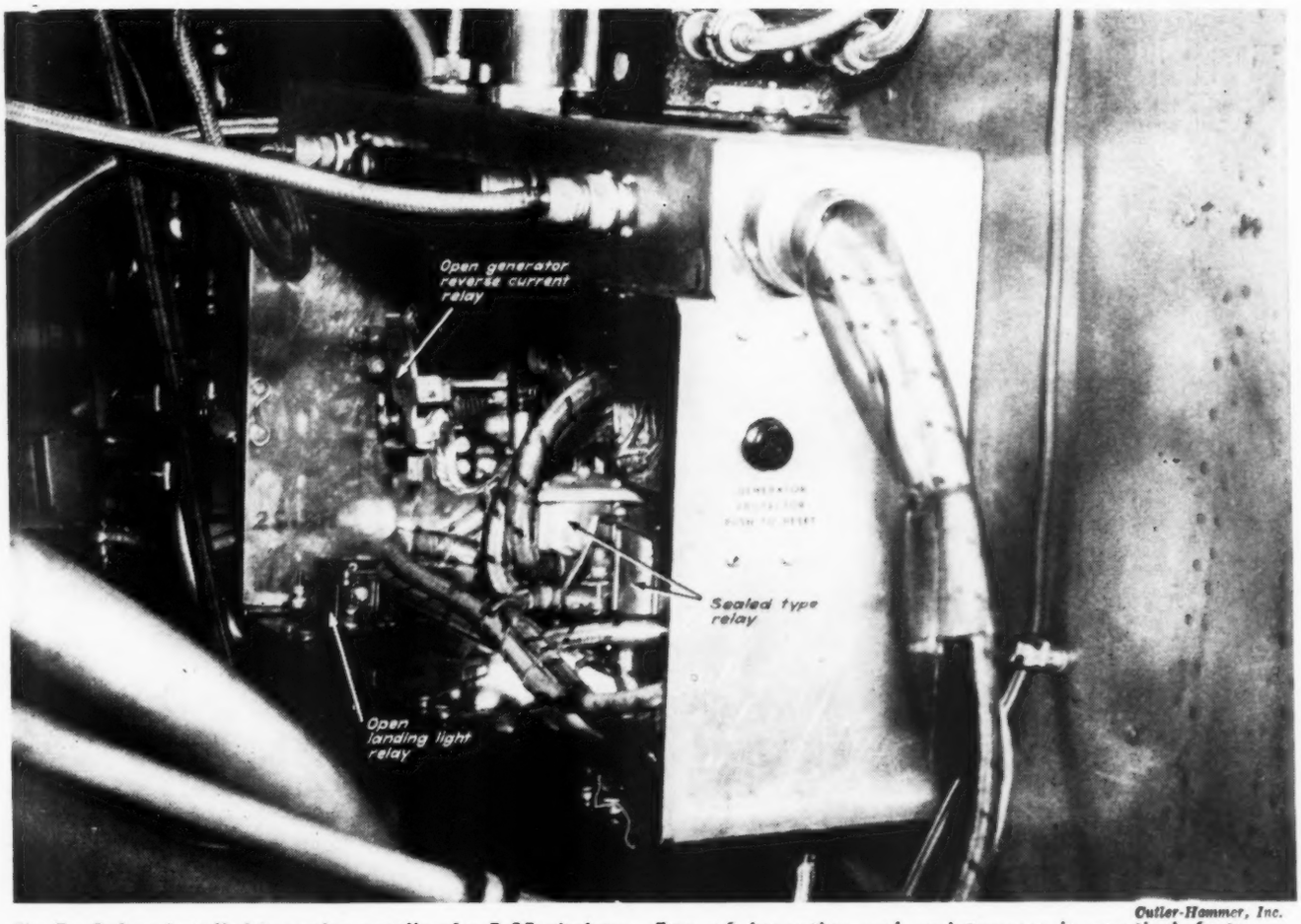
Cutler-Hammer, Inc.

Fig. 5—Solenoid operated single pole single throw relay, typical of sturdy, compact design.



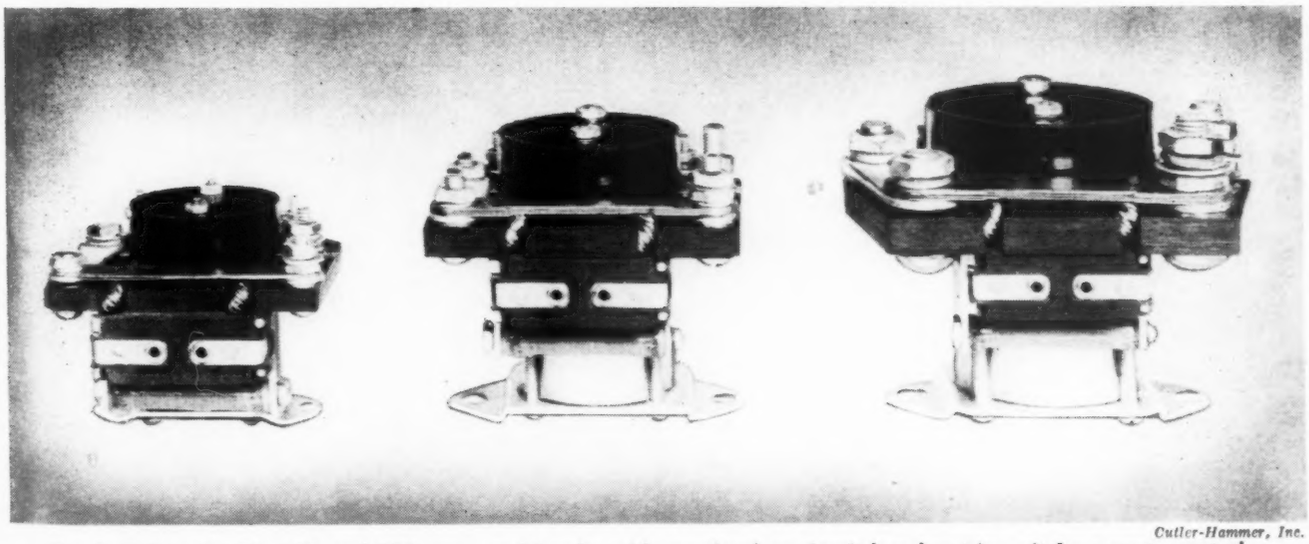
Cutler-Hammer, Inc.

Fig. 6—Two single pole relays combined into a double pole 200 amp., 24 volt reversing relay. Important relay parts are effectively sealed.



Cutler-Hammer, Inc.

Fig. 7—Relays installed in engine nacelle of a B-25 airplane. Ease of inspection and maintenance is practical factor.



Cutler-Hammer, Inc.

Fig. 8—Relays for 50, 100 and 200 amp. at 24 volts with overload as circuit breaker trip unit for remote control.

or circuit breaker which could not be reset in flight.

During the last ten years, outstanding progress has been made in the design of aircraft relays. Aircraft designers have continuously demanded and received increasing performance with reduction in size and weight.

This trend must continue. In commercial aircraft there is a continuing interest in the electrical solution to accessory problems. This will press the demand for relays and will increase the variety of problems. A trend in military aircraft was initiated by the German weapons, the *V*-1 and *V*-2. The *V*-1 with its preset flight and the *V*-2 with its tremendous speed and altitude, bring new performance standards and greater environmental problems to relays. The weapon of the future is a pilotless aircraft that will make one flight. During that one flight the aircraft and everything in it must work perfectly. Yet it will be making that one flight after storage for months or years. Relays will be an important link in such aircraft and they must fulfill the obligation that goes with such usage.

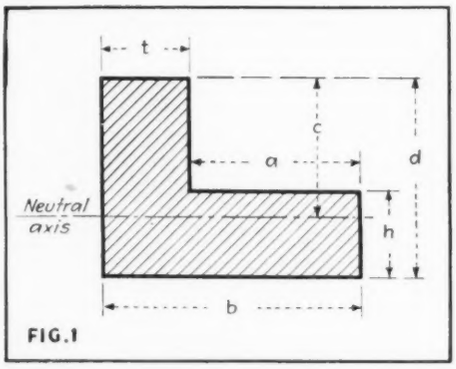


FIG.1

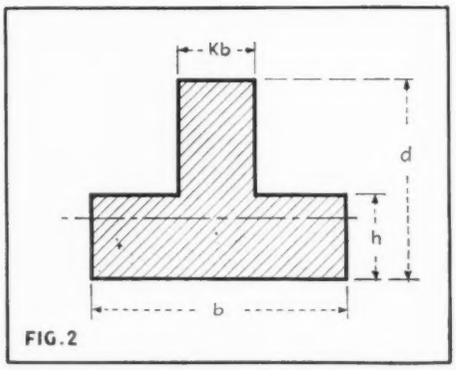


FIG.2

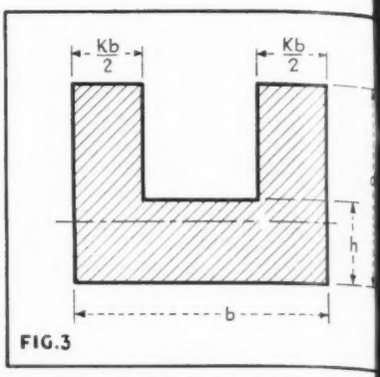


FIG.3

The proportions for these ribbed beam sections which will have the same extreme fibre stress as the beam without a rib can be determined by applying the same mathematical formula, since their section moduli are the same.

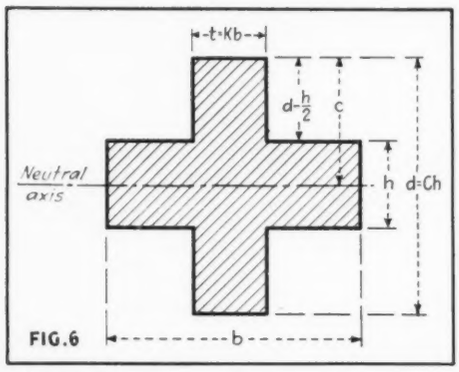


FIG.6

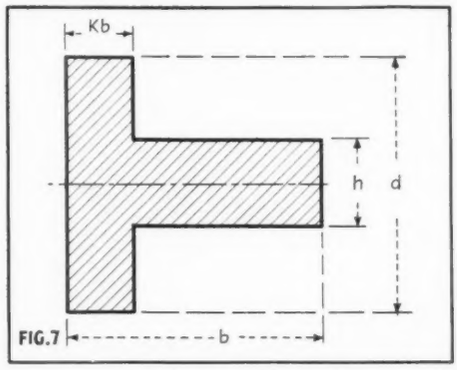


FIG.7

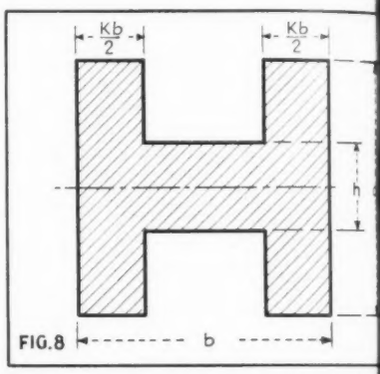


FIG.8

These ribbed beam sections have the same section modulus but since this modulus is different from that of the sections shown in Figs. 1-3 they require the application of a different mathematical formula to determine their correct proportions.

Effect of Rib Proportions on Beam

How rib proportions influence bending strength. Curves are developed for proportions of ribbed beam sections that have the same extreme fibre stress as the beam without a rib.

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Assistant Professor of Mechanical Engineering,
Purdue University

THE addition of ribs to beams to reduce deflections and thus increase stiffness, may result in increased bending stresses that will actually weaken the beam if the ribs are not carefully proportioned. The mathematical analysis presented here develops curves for rib proportions that give stresses in the ribbed beam equal to the stresses in the beam without a rib.

When ribs are added to a beam section, the extreme fibre stress in the section is increased if the ratio of the moment of inertia of the section to the distance of the extreme fibre from the neutral axis is decreased. Or, stated in another manner, for a given bending moment, the stress in the section is inversely proportional to the section modulus. This is shown by the following equations:

Where s = bending stress, psi
M = bending moment, in-lb
c = distance from neutral axis to extreme fibre, in.
I = moment of inertia, in.^{4}
Z = section modulus = I/c, in.^{3}

$$s = \frac{Mc}{I} = \frac{M}{I/c} = \frac{M}{Z} \qquad (1)$$

Therefore, if M is constant, s is inversely proportional to the section modulus.

The proportions for a ribbed section, as shown in Fig. 1, which will have the same extreme fibre stress as the beam without the rib, can be determined by setting the section modulus of the beam section without a rib equal to the section modulus of the ribbed section.

Where b = beam width, in.
h = beam thickness, in.
d = depth of section, in.
t = rib width, in.
$a = (b - t)$, in.

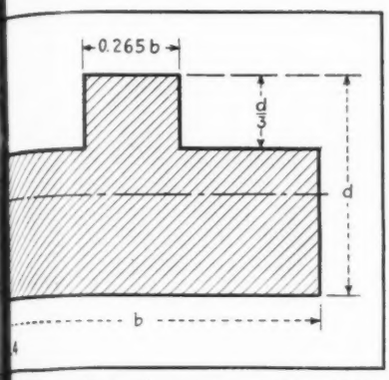
The section modulus Z_1 for the beam is:

$$Z_1 = \frac{I_1}{c_1} = \frac{bh^3/12}{h/2} = \frac{bh^2}{6} \qquad (2)$$

The section modulus Z_2 for the ribbed section is:

$$Z_2 = \frac{I_2}{c_2} = \frac{\frac{(d^3t + ah^3)}{3} - \frac{(d^2t + ah^2)^2}{4(dt + ah)}}{d - \frac{(d^2t + ah^2)}{2(dt + ah)}} \qquad (3)$$

By equating (2) and (3) and



rib section drawn to scale, which as correctly proportioned dimensions.

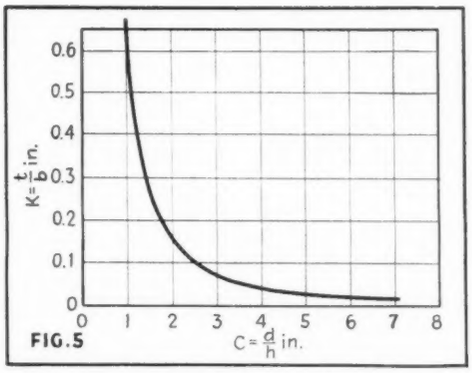
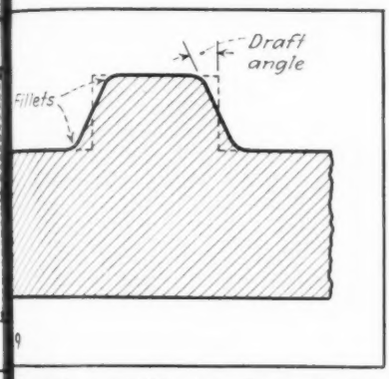


FIG. 5

A curve that can be used when proportioning sections shown in Figs. 1-3.



ib section modified to fit production ractice and reduce corner stresses.

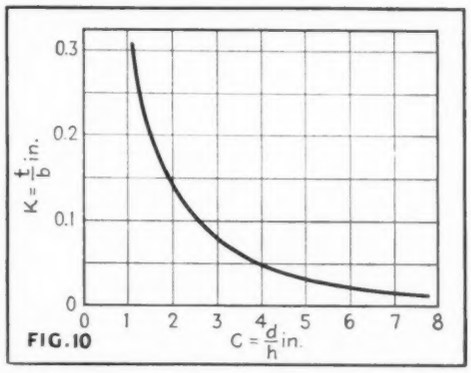


FIG. 10

This curve is used to select proportions for ribbed sections shown in Figs. 6-8.

Bending Strength

making the following substitutions:

$$C = \frac{d}{h}$$

$$K = \frac{t}{b}$$

$$a = b - t$$

the following equation is obtained:

$$K^2 (C^4/2 - 2C^3 + 3C^2 - 2C + 1/2) + K (2C^3 - 3\tfrac{1}{2}C^2 + 3C - 1\tfrac{1}{2}) - C + 1 = 0 \quad (4)$$

Values of K for varying ratios of section depth to beam thickness are given by Equation (4), where the extreme fibre stresses in the ribbed beam and the beam without a rib are equal. If the width of the rib is less than Kb, the section modulus of the ribbed section will be less than that of the unribbed section. This condition results in an increased bending stress in the ribbed section.

As an example consider a section for which C is 1½. The value of K from Equation (4) is 0.265. For such a ribbed section, with the width of rib 26½ percent of the beam width, the same maximum extreme fibre stress will result for a given bending moment as in the beam without the rib. A rib section is drawn to scale in Fig. 4 to illustrate this condition where the addition of the rib has not changed the section modulus. When a rib having a width greater than 26½ percent of the beam is used, the section modulus is increased thereby decreasing the extreme fibre stress.

Substitution of different values for C in Equation (4) gives values of K from which the curve shown in Fig. 5 is obtained. This curve gives the minimum width of rib for a given ratio of section depth to beam thickness where the section modulus of the plate is not reduced. Dimensions of a ribbed beam section that give points lying to the left of the curve indicate a section modulus less than the beam without a rib. Correctly proportioned ribbed sections will give points lying on or to the right of the curve. The curve given in Fig. 5 applies also to the tee and channel sections shown in Figs. 2 and 3, since the section modulus may be expressed as in Equations (2) and (3) and reduced as before.

A similar analysis for the ribbed beam shown in Fig. 6 can be made as follows:

The section modulus Z_3 of the section = $\frac{I_3}{c_3}$

or $Z_3 =$

$$\frac{2\left[\frac{Kb\left(\frac{Ch}{2}\right)^3}{3} + 2\left\{\frac{\left(\frac{b}{2} - \frac{Kb}{2}\right)\left(\frac{h}{2}\right)^3}{3}\right\}\right]}{\frac{Ch}{2}} \quad (5)$$

Equating Equations (2) and (5) the following equation is obtained:

$$K = \frac{C - 1}{C^3 - 1} \quad (6)$$

The plot of Equation (6) is given in Fig. 10. On this curve as in Fig. 5, a correctly proportioned ribbed beam section will give points lying on or to the right of the curve. The curve also applies to the sections shown in Figs. 7 and 8.

The preceding analysis gives theoretical proportions for ribbed beams where extreme fibre stress is an important consideration. It should be remembered that the addition of a rib section of any proportions to a beam will stiffen it by reducing the deflection, since the amount of deflection depends on the moment of inertia and not the section modulus. This is shown by the following equations:

Where Δ_1 = deflection of plate without rib in.
Δ_2 = deflection of ribbed plate, in.
E = modulus of elasticity of material, psi
I_1 = moment of inertia of the plate, in.⁴
I_2 = moment of inertia of the ribbed section, in.⁴
K = constant depending on length and type of support of beam, and type of loading

For a given loading and beam length

$$\Delta_1 = \frac{K}{EI_1} \quad (7)$$

$$\Delta_2 = \frac{K}{EI_2} \quad (8)$$

Since $I_2 > I_1$, $\Delta_2 < \Delta_1$

Rib sections are usually filleted to avoid stress concentrations that would cause fatigue failure and also to facilitate manufacturing. A typical modification for a cast rib section is shown in Fig. 9. Stress concentrations can also develop from residual stresses created by manufacturing operations.

ENGINEERING ABSTRACTS

FOREIGN AND DOMESTIC ARTICLES

Hardness Testing With a Ball Trace

Foreign Abstract condensed from "Hardness Testing With a Ball Tracing Machine" by H. Hauttman, Stahl and Eisen, September 2, 1943, page 641.

A BALL TRACING MACHINE, developed for investigating hardness of metals resulting from cold work, is particularly applicable to materials where the effect of the speed of cold drawing and rolling processes on the ensuing hardness are to be determined. The machine can also be used for hardness tests on welded or heat-treated parts.

In the instrument a ball is freely suspended and rolled at constant load over the specimen that moves on a slide beneath the ball at a specified velocity, Fig. 1. The ball is carried by a lever arm of constant length and can be moved in a plane perpendicular to the axis of the arm. The width and the depth of the trace left by the ball on the specimen are taken as a means for determining the Brinell hardness caused by cold rolling. The machine can also be used for testing variations in hardness as a function of time.

In one size of machine the slide can be moved at velocities between 0.2 and 1,000 mm. per sec. The total length of stroke of the slide is 200 mm. corresponding to a trace 100 mm. long. The standard ball is 2.5 mm. dia. and the standard load is 80 kg. The design of the specimen carrier attached to the slide assures that the specimen is always in a horizontal position. Parallel traces can be drawn by shifting the specimen laterally with a cross motion.

To avoid vibrations, which may occur at high speed when the ball suddenly starts to move after the initial identation has been made, a device relieves the ball from the load so that the specimen is penetrated only slightly. The load is then increased gradually to its maximum as the slide continues to move.

To determine the effect of the speed of rolling on the hardness for various types of steels, a uniform initial deformation of the material is adopted as a standard and the changes are observed as a function of the speed.

Preliminary tests indicate that for accurate measurement of the width of trace the most favorable conditions are secured when the depth of penetration is about 1/3 the diameter of the ball.

The forces acting on the ball are indicated in Fig. 2. When the width of the trace is small, it is admissible to as-

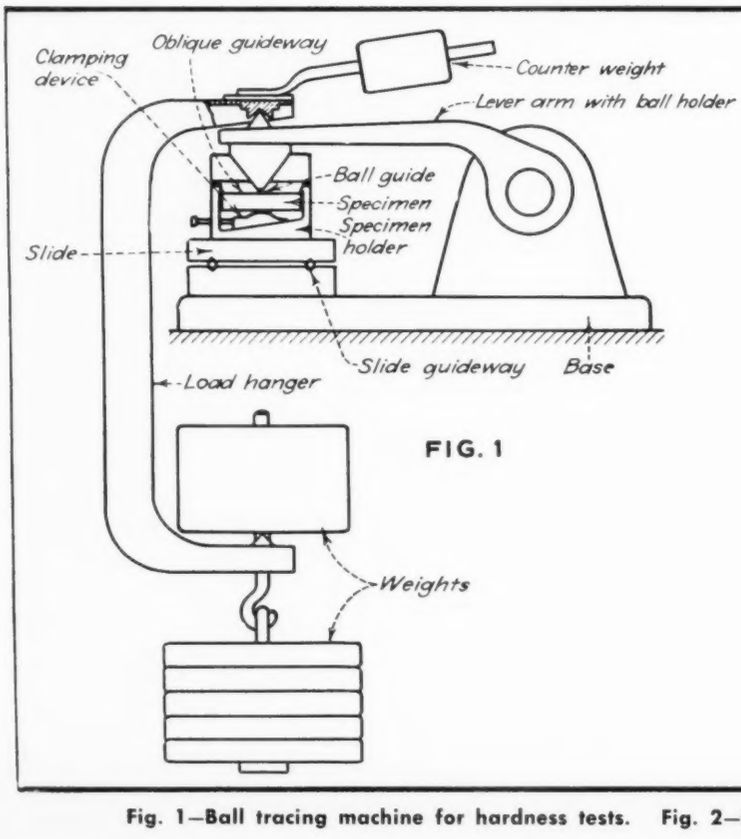


FIG. 1

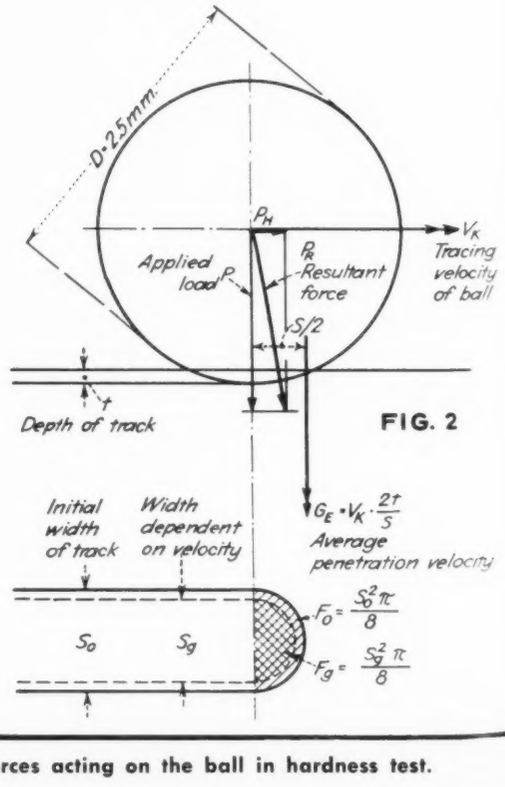


FIG. 2

Fig. 1—Ball tracing machine for hardness tests. Fig. 2—Forces acting on the ball in hardness test.

sume that the resultant force P_r equals the applied load P. Accordingly, 0.745 mm. was adopted as the initial value for a trace of uniform width.

The highest speed that can be used in the tests is indicated by the appearance of vibration marks on the specimen that cannot be further avoided by controlling the rate of load application. The mean velocity G_E of penetration of the ball into the material is used as a criterion for the speed of deformation of the specimen. G_E is calculated from the tracing speed V_K, the width of the trace S, and the depth of the trace t using the formula

$$G_E = 2\ V_K t/S$$

This calculated speed represents an average of the maximum speed and refers to the plane of the largest circle rolling in the track. The mean penetration velocity of the ball lies between 0.015 and 49.96 mm. per sec. The initial standard trace 0.735 mm. wide is produced at 0.015 mm. per sec. penetration velocity.

In Fig. 2 and the following analysis, all quantities referring to the initial conditions are indicated by the subscript "O", and those referring to higher speeds by the subscript "g". The effect of speed can best be determined from changes in the ratio F_o/F_g, where F_o denotes the half circle area for the width S_o produced at minimum speed of penetration, while F_g correspondingly refers to the area for the width S_g obtained at any other speed with the same load P. The change in the specific pressure σ_D, or change in the resistance to deformation, follows from the ratio F_o/F_g as indicated by

$$\sigma_{Dg} = \sigma_{Do}\ F_o/F_g$$

likewise, the variation in the "roll hardness" H_r depends upon this ratio

$$H_{rg} = H_{ro}\ F_o/F_g$$

It has also been found that the ratio F_o/F_g can be used in conjunction with load P_o for calculating the load P_g that would produce the initial width of 0.735 mm. at a higher penetration velocity.

Under the conditions of the tests that have been carried out, the load P_o and the Brinell hardness H_n are correlated according to the formula

$$P_o = H_n/3.25$$

Thirty four different steels were tested. Each steel was investigated after two different heat-treatments, namely, after a "normal" heat-treatment (small grain size) and after 1,100 deg. C. (coarse grain size) heat. The specimens were so selected that the direction of the fibers resulting from rolling in the rolling mill was perpendicular to the direction of relative motion of specimen and ball.

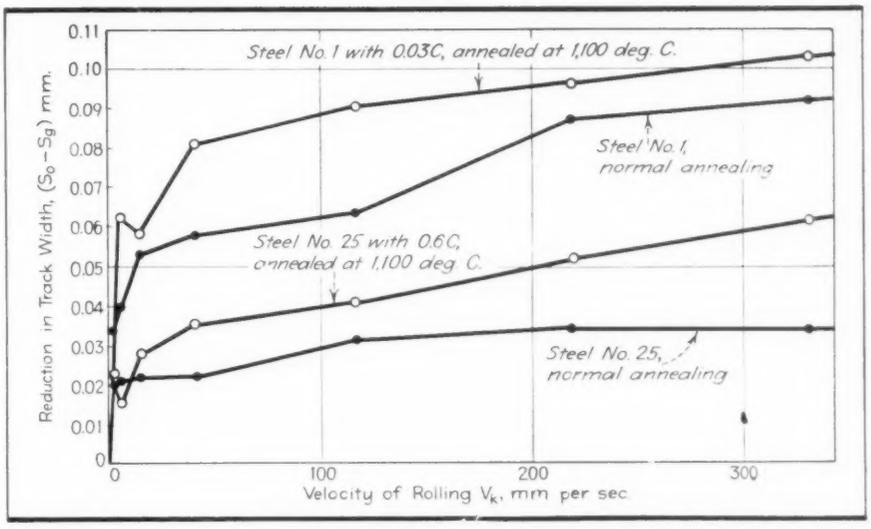


Fig. 3—Relationship between the width of track and roll velocity of the ball.

Uniformity of hardness was tested by tracing three tracks at different places on the specimen by applying load P_o at a velocity of 0.1 mm. per sec. A deviation from the standard width of 0.735 mm. of plus or minus 0.002 mm. was admitted in the case of normal heat-treatment, and plus or minus 0.005 mm. in the other heat-treatment. The tracks were drawn at a distance of 3 mm. to exclude any mutual distortion.

Test Results. The reduction in width of the trace with increasing speed can be seen from Fig. 3, where the difference S_o minus S_g is plotted against the rolling speed V_K. It will be seen that the width decreases fast at first with increasing speed, but to a lesser degree as the speed is further increased. The effect of carbon content on this relationship can also be seen from Fig. 3. The increase in speed has less effect on the change in the width when the carbon content is high than when the carbon content is low.

Evaluation of the F_o/F_g ratios determined from the decrease of the width of the trace allows derivation of an empirical law to the effect that the ratio F_o/F_g increases proportionally to the logarithm of the velocity G_E of penetration.

A comparison of test data and calculated loads shows good agreement within the limits of errors in measurement. Clear relationships are obtained by plotting the percentage increase of the ratio F_o/F_g as a function of the tensile strength on double logarithmic paper. The data of the tests for all steels arrange about a straight line regardless of heat-treatment or composition of the steel for a penetration speed between 0.015 and 0.50 mm. per sec. Also, the arrangement of the data is not appreciably affected by the modulus of elasticity, the impact strength nor of any other criterion for the strength of the materials. On the basis of the straight line relationship of the logarithmic values, it is possible to develop a general diagram as indicated in Fig. 4. From this diagram the percentage increase in the resistance to deformation of the material can be read with respect to both speed and tensile strength.

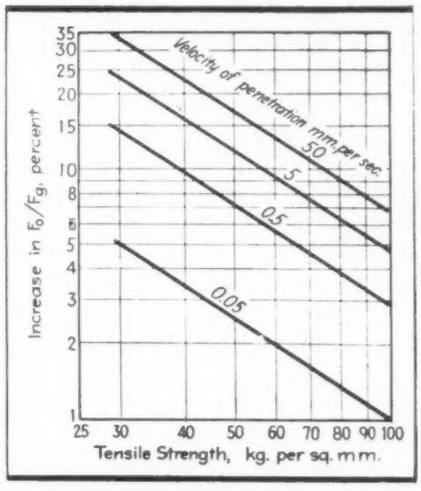


Fig. 4—Relationship between the percentage increase in resistance to deformation and the tensile strength for different velocities of penetration.

It is surprising to learn that the resistance to deformation of soft steels is more affected by the speed than that of hard steels. An increase in the penetration velocity from 0.015 to 50 mm. per sec. requires 8 kg. more load at the ball for steels with a tensile strength of

35 kg. per sq. mm. as against an increase in the load of 6 kg. for steels with 90 kg. per sq. mm. tensile strength, based on the same deformation. It is assumed that the excess in work required for overcoming internal friction with increasing velocity is caused by the blocking of the shear planes, which affects softer steels more than harder ones because of the higher ferrite content of the soft steels.

Tin Coatings on Mild Steel

From "Tin and Its Uses, No. 18," Tin Research Institute, England. Copies can be obtained from the Battelle Memorial Institute, Columbus, Ohio.

AN EXTREMELY THIN COATING of tin, 0.00005 in. thick, on mild steel before painting is found to provide an exceptionally good rust resisting combination. For purposes of comparison a number of identical steel panels were painted directly, omitting the tin undercoat, and a further series was painted after different rust-prevention treatments. Tests with steels of many types and several paint compositions, including linseed-oil paint, nitrocellulose lacquer, stoving paints and air-drying japans, have been carried on for more than four years and in every case those specimens that had been pre-tinned have retained their paint longest.

An even more important finding is that the pre-tinned specimens have retained a clean tinned surface free from rust, which can be re-painted without preliminary scraping and cleaning operations, whereas, the surfaces of the untinned steels have rusted underneath the paint. Photographs in natural color show marked differences in the condition of the tinned and the untinned steels and also the protective value of tin as an undercoat for painted steel.

The use of pre-tinned steel would do much to improve the appearance and prolong the life of motor car body work and other painted steel products. The costs of applying an undercoating of tin, from 0.00003 to 0.00005 in. thick, to both surfaces of a sheet of steel are estimated to be less than a quarter of the charges for labor and materials required to apply a single coat of paint to only one side of the sheet.

Low Pressure Molding

From "General Techniques of Molding and Finishing Low-Pressure Molded Products," by A. E. Wiles, General Electric Co. Presented January 24, 1947, at the Low Pressure Industries meeting of Society of the Plastics Industry, Chicago, Illinois.

MOLDING PRESSURES for low pressure molding and laminating range from 5 to 100 lb. per sq. in. when a rubber plunger is used as a pressure medium, and from 5 to 80 lb. per sq. in. where the pressure is applied by means of an inflated rubber bag or diaphragm.

Items selected for low pressure molding should be those which now require considerable skilled direct labor for their manufacture. The manufacture of boats is a good example of a product adapted for low pressure molding. The present method of manufacturing boats of wood requires many hours of labor by skilled craftsmen. As a result, production is low and the cost is high even though each boat is built around standard lines. Low pressure molding makes possible the manufacture of that type of boat which could not previously be realized because of the limitations of wood.

Part designs originally intended for fabrication from wood or metal usually are not satisfactory for low pressure molding because they lack the large sweeping radii that are desirable. Good draft should be provided on all side wall sections with as few as possible undercuts. In the last year, however, some methods have been developed for successful molding of undercuts, but these add to the cost of the finished part. It is also possible to mold in at the initial step many inserts of wood, paper, metal, or plastic. The part can be reinforced with wood, many types of rope or foam molded within the structure.

Low pressure molded parts should be designed, engineered, and tooled to call for minimum finishing labor. Engineering of the part and tool design should aim for the lowest possible direct labor content. Investigation should be made of all possible methods of repair and salvage of molded parts which may not fill out because of lack of pressure or lack of resin at a particular point. Material selection is of vital importance. Many times the highest cost material will justify its use by the reduction of labor content in the part. Large low pressure molded parts should be designed for mold finish on one side only.

There are many filler materials available for low pressure molding including various types of woven, knitted, or mat materials: Glass, cotton, paper, rayon, nylon, jute, hemp, and many others. The most practical material has been found to be a random arrangement of fibers since they are best adapted and suited for layup around compound curved surfaces. Sheet material such as paper, felt, or woven cloth require tailoring in order to accomplish the same result.

In addition to the many filler materials, there are available an equally great number of resins or binders available for low pressure molding. Paper or cloth treated with a phenolic type resin and with volatiles evaporated, is usually referred to as a "dry type" of material. All of the others, since the buildup process is accomplished in a tacky state, are referred to as "wet materials". For reinforcement or flotation cells, the various plastic foam materials, balsa wood, and various honeycomb structures of formed paper and glass are the most practical available today.

There are many types of molds used for low pressure molding, and they are generally classified as male or female depending on the surface requirements of the part. No production method of getting smooth uniform surfaces on both sides of a large low pressure molded part has yet been found. The quantity and quality of low pressure molded parts largely determines the type of mold and mold materials.

Plaster molds of the male type and a few of female type are still used for special parts where the quantity required is exceptionally low. The most successful molds are those fabricated from sheet metal. These sheet metal molds are made by spinning, or hammering over form blocks, or welding to shape. All production type molds designed at present are "self-contained." To further reduce mold cost, this self-contained type of mold is built to fit into a cylindrical tank which is divided in the center so that the mold may be opened. This type of mold makes possible a removable cavity and eliminates the use of an autoclave. The latter is one of the most expensive methods of low pressure molding since the quantity of steam required, and the direct labor content is much higher than that for molding in self-contained molds.

The extent to which a low pressure molded or laminated part requires finishing is wholly dependent upon its end use. In practically all cases the part must be trimmed at the free edges or the parting line of the mold. Decorative surfaces can be obtained in many ways. The simplest is to paint the part

with any one of the many types of paints or enamels on the market. Another method to impart a single color on the surface is by using a mold coating where a heavily pigmented resin is applied to the mold prior to the lay up of the impregnated material. During the molding cycle, this heavily pigmented resin becomes bonded to the part—thus imparting surface color. Still another method is to lightly sand the exterior of the part and apply one of the transfer films which are commercially available, such as is widely used in the automotive industry for interior body trim.

Brineiling of Ball and Roller Bearings

Foreign Abstract of "A Study of Rhythmic Phenomena in Roller Bearings" from Schweiz. Technische Zeitschrift, Zurich, November 1946, Vol. 43

BALL AND ROLLER BEARING FAILURES can result from light, high frequency impacts repeatedly striking the same area in the periphery of the bearing races. The apparent cause for failure is the expulsion of the oil film from the surfaces between the rolling parts and the races, which results in metal to metal contact and subsequent indentations in the races. Vibrations induced in ball and roller bearings can be harmful in this respect not only when the bearing is in operation, but also when the parts are motionless. The following discussion gives details and calculations from experiences in reducing bearing failures caused by vibrations.

STATIC VIBRATION. Generally speaking, vibrations are more harmful to roller bearings in the motionless position than when they are running because the same area is being struck repeatedly by the impacts. Ball bearings are not as sensitive to static vibration since they are usually made with smaller clearances than are roller bearings.

Vibration without rotation can, for example, occur in the roller bearings of machines in transit on railroads or ships. Vibrations of neighboring machinery such as stone breakers, internal combustion engines or machines that are rotating rapidly and out of balance can also harm roller bearings in non-operating machines. Under these circumstances the conditions may be so unfavorable as to cause bearing failures in a fraction of the time of service life that the bearings would otherwise have given under conditions of heavy loading and high rotating speeds.

Vibrations during shipping are to a large extent resisted without damage by roller bearings in small machinery, while medium and large size electrical machinery often require that suitable protective measures be taken to prevent damage to the bearings. For example, cylindrical roller bearings supporting a rotor weighing 500 lb. can have their useful life considerably shortened after a railroad journey of as short as one hundred miles.

Three principal methods can be adopted to reduce damage to roller bearings in machinery that has to be transported. The most effective method is to remove the bearings and ship the machine disassembled. Another method consists of fixing the rotating shaft and pinning down the bearing so as to allow no movement. The final solution is to damp out the vibrations of shipping by placing rubber, felt, cork, leather or an arrangement of metallic springs underneath the base of the machine. The expense of reassembly and added shipping charges usually nullify the first method.

When roller bearings in non-operating machinery are subject to vibrations from surrounding machinery, the conditions can be corrected by either rotating the bearing continually at slow speed or by a combination means of fixing the shaft and damping out the vibrations with springs placed under the base of the machine.

VIBRATIONS WITHIN THE BEARING. Vibrations within ball bearings can result from bearing clearance, ball spacing and elastic deformation of the balls. This can be demonstrated by an example from practice that deals with a large synchronous induction generator designed for a maximum speed of 3,000 r.p.m. Although carefully balanced, this machine was found to run unsteady at speeds from 1,400 to 2,750 r.p.m. The first critical speed of revolution was calculated to be 4,360 r.p.m., thus providing no explanation for the conditions that existed.

The rotor was supported on two No. 6315 Swiss ball bearings with internal and external diameters of 75 and 160 mm. respectively. Each of these bearings had 8 balls of 26.987 mm. dia. with a central orbit of 117.5 mm. dia. The diameter of the inner running track was 90.5 mm. The turning speed of the track was $284.3n$ mm. per min. where n was the rotating speed of the shaft in rev. per min.

The peripheral speed v_c of the balls therefore was ½ the track speed or $142.15n$ mm. per min. with a ball distribution t_c of

$$t_c = \frac{117.5\,\pi}{8} = 46.16 \text{ mm.}$$

Thus, at any point on the fixed external ring there were passing

$$\frac{v_c}{t_c} = \frac{142.15\,n}{46.14} = 3.08n \text{ balls per min.}$$

A half section of this bearing is shown in Fig. 1. The bearing clearance is l. Line A shows the theoretical central position of the inner race. Line B, shown dotted, is the position the inner race assumes because of the ball gap below. Line C, dot and dash line, is the position of the inner race as the ball passes the vertical center line.

Because of the bearing clearance and elastic deformation an impulse is generated by the sudden rise of the shaft by the amount Δh. The value of Δh naturally decreases with an increasing number of balls.

For a rotating speed n of 1,400 r.p.m. the impulse period i_1 was

$$i_1 = 3.08 \times 1{,}400 = 4{,}312 \text{ r.p.m.}$$

for $n = 2{,}750$

$$i_2 = 3.08 \times 2{,}750 = 8{,}470$$

The impulse period thus almost coincided at 1,400 r.p.m. with the first critical period of revolution at 4,360 r.p.m., and caused maximum vibration.

Although the second critical speed was not calculated, it was safe to assume that the other maximum vibration period at 2,750 r.p.m. had a similar relationship.

The vibration was eliminated by the installation of dual row roller bearings that had more than 8 rollers.

VIBRATIONS IN COUPLED MACHINES. This example concerns an electric generator turning at a speed of 750 r.p.m. that was coupled to a Pelton type water turbine with 20 buckets. Three roller bearings were used in the installation.

After a relatively short time, vibration developed in the roller bearing on the driven side. An examination of the bearing showed visible indentation

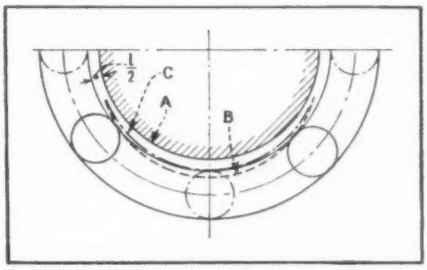


Fig. 1—Diagram of ball bearing showing ball passing centerline, causing sudden rise of shaft and vibration.

marks about ¾ mm. apart in the center of approximately one-half of the circumference of the outer race. These markings were found to be the impressions of the slightly crowned hard rollers in the running path of the outer race. The width and length of the markings increased with the distribution of the impact force around the bearing. The bearing had 12 rollers 24 mm. dia. The central orbit of the rollers was 132 mm. The diameters of the running paths were 108 and 156 mm. The roller center moved at a velocity v_c equal to one-half the speed of the inner ring.

$$v_c = \frac{108 \times \pi \times 750}{2 \times 60} = 2120.58 \text{ mm. per sec.}$$

Since v_a, the velocity of a point on the roller at the diameter of the outer track is proportional to the distance to the roller center

$$v_a = 2120.58 \times \frac{156}{132} = 2506.12 \text{ mm. per sec.}$$

The waterflow on the buckets caused s impacts per second and

$$s = \frac{750 \times 20}{60} = 250 \text{ inpacts per sec.}$$

The movement of the roller crown, measured at the outer track diameter per impact was

$$t_c = \frac{v_a}{s} = \frac{2506.12}{240} = 10.0245 \text{ mm.}$$

The opening of the rollers, t_a at 156 mm. dia. was

$$t_a = \frac{156\,\pi}{12} = 40.841 \text{ mm.}$$

Thus, with the first bucket impact, impressions at a distance of 40.841 mm. apart were formed by the lower rollers in the running ring. The second impact produced at the same spacing a further series of impressions displaced 10.0245 mm. from the first impressions. The third impact gave impressions that were displaced 20.045 mm. Similarly the fourth impact gave impressions that were displaced 40.098 mm. Consequently in the distance 40.841 minus 40.098 or 0.743 mm., a series of marks are formed. This last dimension compared with the measured distance of ¾ mm. on the outer race. After four more bucket impacts, there were formed another series of impact notches that were displaced 0.743 mm. as before. In the distance of 40.841 mm. there were thus formed

$$\frac{40.841}{0.743} = 75 \text{ marks.}$$

It was doubted that indentations could appear in the races in so short a time, especially since the rotor weighed 1,500 lb. and the impulse wheel weighed 1,240 lb. Resonance phenomena was therefore suspected. The coupling shaft supported by the three roller bearings was examined for a critical rotating speed.

The first critical speed was found to be at 3,130 r.p.m. and the second at 6,120 r.p.m., while the induced frequency of the water flow was 750 times 20 or 15,000 cycles per min. Thus, at 15,000 r.p.m. resonance occurred.

A resonance effect will still occur with a critical shaft rotating speed of 3,000 r.p.m. since each fifth hydraulic flow impact gives a rocking action. Allowing for small inaccuracies, the calculated critical speed of 3,130 r.p.m. agreed with the 3,000 r.p.m. value within five percent. Therefore the presence of resonance effects was substantiated apart from the fact that at 15,000 r.p.m. a critical period existed.

The vibration problem in this instance was solved by the installation of a friction bearing on the driving side of the coupling shaft.

Ingenious A-C Adjustable Speed Drive

From a paper "A New Drive for a New Machine for a New Technique" by W. E. Happel, Landis Tool Co., presented at the 1947 Westinghouse Machine Tool Electrification Forum, Buffalo, N. Y.

AN INGENIOUS and extremely simple a-c adjustable speed drive with substantially flat speed regulation is used to power the regulating wheel on the Landis Tool centerless grinder.

The driving motor is rated 1 hp at 600 rpm but is adjustable by rheostat control from 600 to 60 rpm, constant torque. A preselectable high speed of 1,500 rpm at 1 hp is available, thus giving an overall 25 to 1 speed range. Relatively, the drive is mechanically and electrically simple with a minimum of control complexity.

Essentially, the system is a separately-excited, series-adjustable-voltage loop circuit, except that a full wave rectifying bridge is connected across the generator and motor field, as shown in Fig. 1.

A rheostat shunts the generator field and a resistor the motor field. The contacts *CR* and the polyphase starter for the m-g set are the only contactors required. The *CR* contacts transfer speed control from the rheostat to the resistor and vice versa.

The speed-load characteristics of a conventional series - adjustable - voltage system are shown by the dotted curves in Fig. 2. As shown, the speed varies appreciably from flat at both low-speed and light-load and high-speed and heavy-load. The speed decreases with load at the light-load end of the curve and increases with load at the heavy-load end, which is undesirable. The decrease under load at the light-load end is caused mostly by generator armature reaction.

At low-speeds and light-loads the generator field is relatively weak because of the practically complete rheostat shunt. Armature reaction distorts the field sufficiently to cause a decrease in generator voltage resulting in a rapid decrease in motor speed with an increase in load. The increase in speed at the heavy-load end is caused by the motor correcting from an unsaturated to a saturated condition. Motor flux varies from very low excitation to full excitation from no-load to full-load. Between no-load and full-load the flux varies directly with load current and no

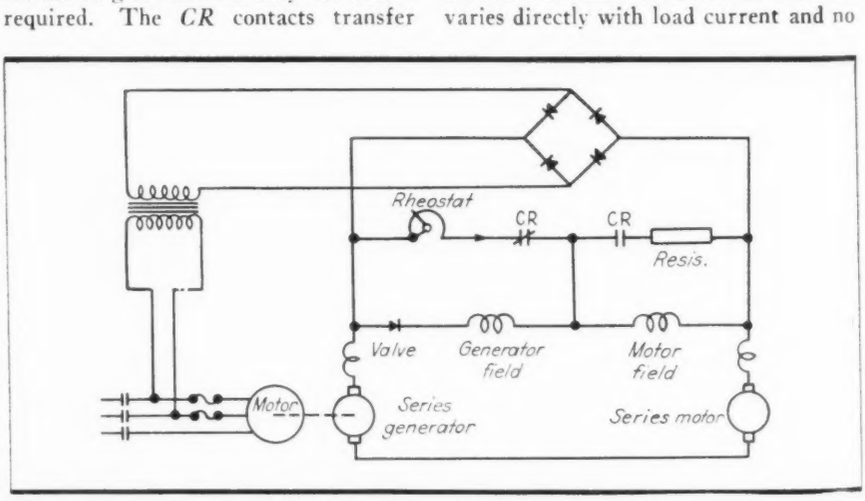


Fig. 1—Separately excited, series-adjustable-voltage loop circuit with rectifier bridge connected across the generator and motor fields.

stability exists. But should the load reach the point of saturation, the motor flux does not increase as rapidly as the generator voltage since the generator may be operating at some point over its unsaturated range. Therefore, the motor speed increases with load until it is limited by the resistance of the circuit or the generator saturates.

In the modified system used on the grinder, external auxiliary excitation for both the motor and general fields successfully flattened out the regulation as shown by the solid line curves in Fig. 2. The curves extend from full-saturation to no-load and through to overhauling-loads.

In operation the auxiliary excitation varies somewhat inversely to the excitation provided by the load current. There are, in effect, two electrical systems both of which include the motor and generator fields in their circuits. The two systems and typical current distribution under different conditions of load are shown in Fig. 3. The load and excitation currents combine to maintain the generator field excitation unaffected by armature reaction. Thus, the generator voltage remains constant for a given rheostat low speed setting and the light-load end of the curve is flattened out. By suitably selecting the rectifier relative to the resistance of its load circuit the motor is always operated at some value of excitation beyond the point of saturation. Thus, the motor never corrects from an unsaturated to a saturated condition. The heavy-load end of the curve is, therefore, flattened.

Current distribution under one condition of overhauling-load is shown in Fig. 4. To hold the motor speed flat by regenerative braking during overhauling, a one way rectifier, or valve, is connected in the field circuit as shown. When the motor is overhauled by the grinding wheel motor through the work piece it becomes generative.

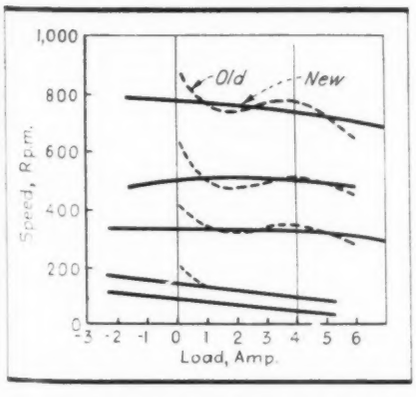


Fig. 2—Compare solid curves showing typical speed regulation of special series-adjustable-voltage systems, with dashed curves for usual series system.

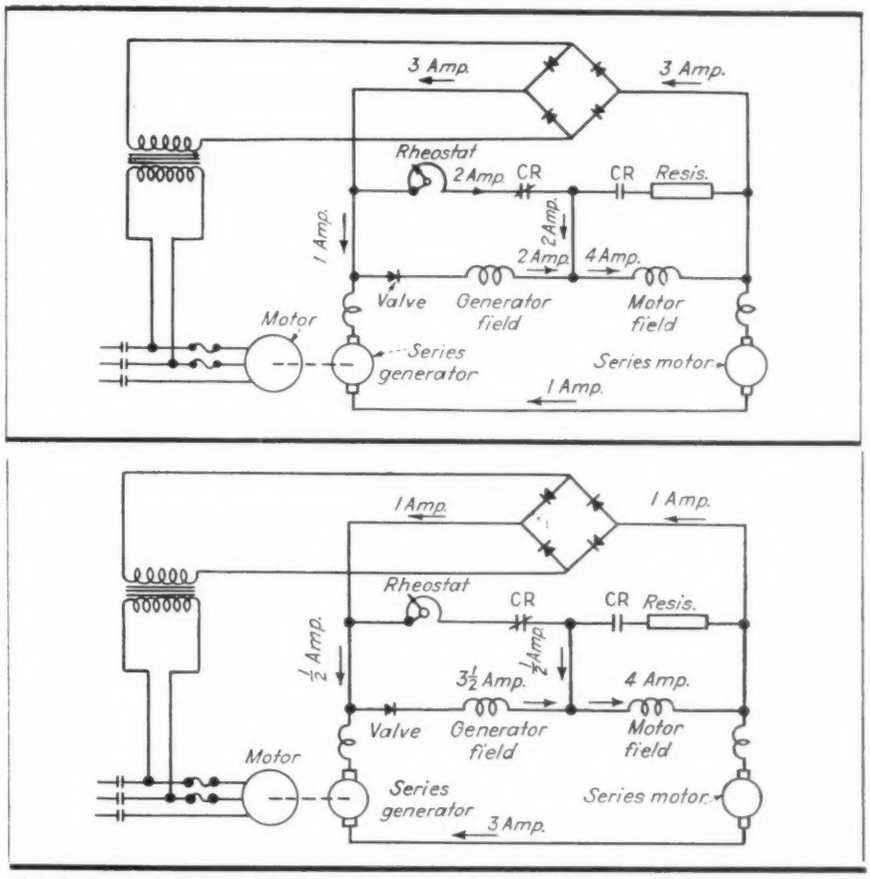


Fig. 3—Typical current distribution in the system for two different load conditions.

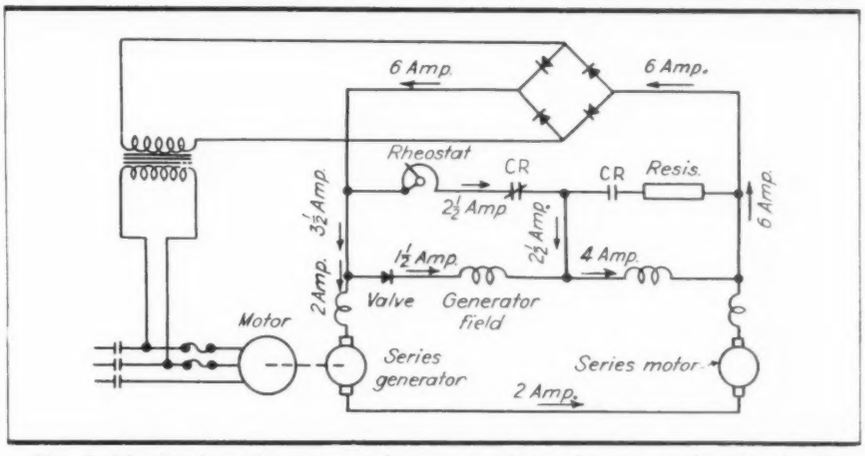


Fig. 4—Distribution of current under one condition for an overhauling load.

This motor generated current is of opposite polarity to that of the generator and would normally flow back through the motor field and decrease excitation. Any decrease in excitation during regeneration would allow the motor to increase speeds. But because of the valve the flow of regenerative current back through the fields as blocked. The only return flow path is through the rectifier, the generator armature, and back to the motor. The rectifier continues to supply full excitation of the correct polarity to the motor field. Thus effective regenerative braking is obtained.

To obtain a low 60 rpm operating speed, a generator magnetic structure with extremely low residual flux is used. For example, the conventional generator has a residual flux from 20 to 12 percent of the no-load saturation flux as compared to the 4 to 15 percent ordinarily used. This, plus the auxiliary field excitation, gives a low motor speed of 60 rpm with quick, sharp voltage buildup. The motor is perfectly stable with excellent commutation at 1,500 rpm by field weakening for wide speed range.

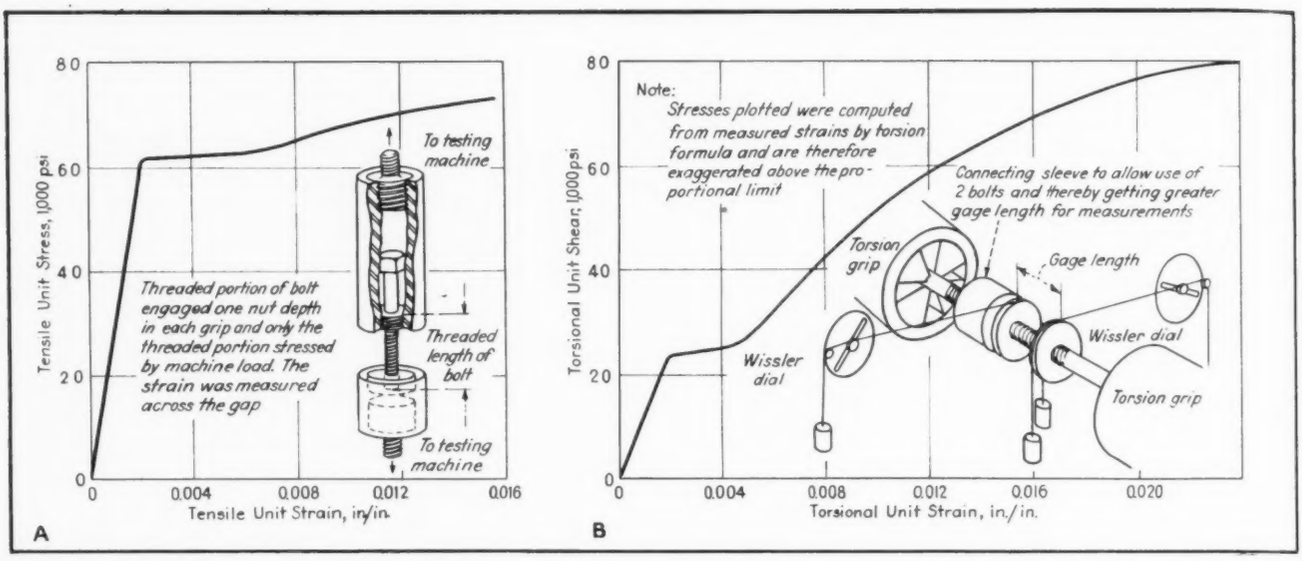


Fig. 1—(A) Typical stress-strain curve of the threaded section of a ½ in. coarse thread bolt in pure axial tension. (B) Typical stress-strain curve of the threaded section of a ½ in. coarse thread bolt in pure torsional shear.

Strength and Clamping Force of Bolts

KENNETH H. LENZEN
Research Associate, Northwestern University

Forces in bolts as tested under tension, torsion, and as torqued by a nut. Includes the derivation of a formula for the torque to be applied to a nut to obtain a desired clamping force. Accuracy of torque-predicted stresses is discussed.

BOLT TENSION can be controlled within reasonable limits by using a torque wrench to set nut torque. The clamping force developed also can be predicted with an accuracy practical for many applications. These facts were determined in an investigation on the action of bolts under combined torsion and tension. The tests, begun in 1945, were made by the American Institute of Nut, Bolt & Rivet Manufacturers at the Technological Institute of Northwestern University.

Two points were investigated:

1. The allowable applied torques for safe tensile and torsional shearing stresses.

2. The clamping force of the bolt under any applied torque and the accuracy with which the clamping force can be predicted for any applied torque.

Since the commonly manufactured bolt has rolled threads, and is made of low-carbon steel, stress-relieved, the tests were conducted on standard bolts of this type from ten manufacturers. The nuts were American Standard Regular dimension. The tests were:

1. Tests in pure tension.
2. Tests in pure torsion.
3. Tests in combined tension and torsion as are applied by the tightening of a nut onto a bolt.

The bolts were tested in pure tension as Fig. 1(*A*) illustrates. It will be noted that strain is considered only in the threaded part of the bolt. The figure includes a typical stress-strain curve of the threaded portion of a bolt. In Fig. 1(*B*) the apparatus to test a specimen in pure torsion, and a typical stress-strain curve are shown.

The combined tensile and torsional strain test set-ups are illustrated in Figs. 2 and 3. The stresses were applied in each case by torquing the nut. In Fig. 2, two SR–4 electric gages were applied on the same cross-section but on opposite sides of the bolt. Each gage had 3 gage lines, one of which extended along the longitudinal axis of the bolt, the other two being placed at a 45 deg angle to the longitudinal axis or 90 deg to each other. As soon as the accuracy of this method was ascertained, the gage line along the longitudinal axis was omitted. Those gages along the axis were used only to check, by direct measurement, the axial tensile stresses as determined by gages on the 45 deg lines. The pairs of diametrically opposite gage lines were used to compensate for any stresses caused by bending. The formulae as given in Fig. 2 are for translating the strain measurements to stresses in torsional shear, transverse shear, and axial tension, respectively. The symbol, μ, in these formulae, refers to Poisson's ratio. This is approximately 0.3 for steel.

In general, about 10 percent of the total torque-wrench energy applied goes toward elongating the bolt along

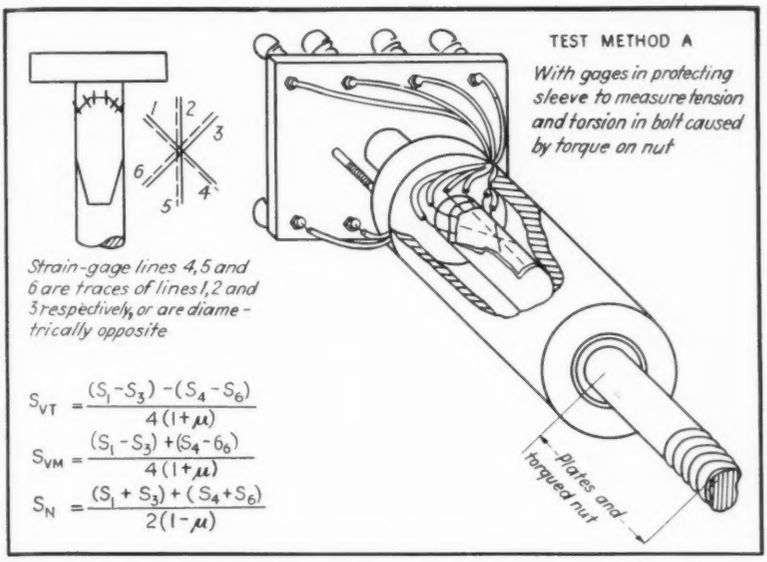

TEST METHOD A
With gages in protecting sleeve to measure tension and torsion in bolt caused by torque on nut
1
2
3
4
5
6
Strain-gage lines 4, 5 and 6 are traces of lines 1, 2 and 3 respectively, or are diametrically opposite
$S_{VT} = \frac{(S_1 - S_3) - (S_4 - S_6)}{4(1+\mu)}$
$S_{VM} = \frac{(S_1 - S_3) + (S_4 - S_6)}{4(1+\mu)}$
$S_N = \frac{(S_1 + S_3) + (S_4 + S_6)}{2(1-\mu)}$
Plates and torqued nut

Fig. 2—The strain gage test method for measuring combined tension and torsion in a bolt as caused by torquing of a nut onto the bolt.

Fig. 3—Showing the test apparatus and application of loads on the bolt by a torque wrench.

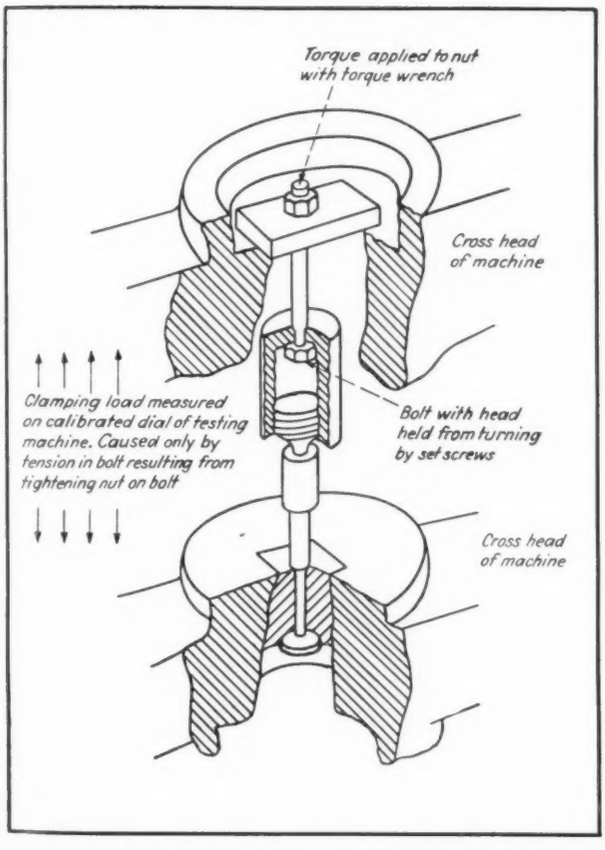

Torque applied to nut with torque wrench
Cross head of machine
Clamping load measured on calibrated dial of testing machine. Caused only by tension in bolt resulting from tightening nut on bolt
Bolt with head held from turning by set screws
Cross head of machine

Fig. 4—The test set up to measure clamping force caused by nut torque, which establishes strain in the bolt.

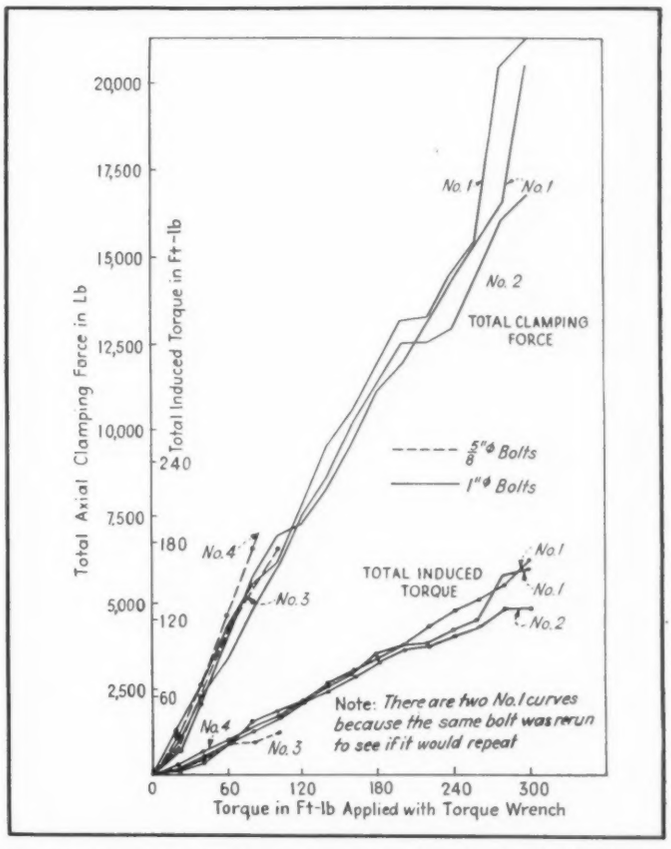


Fig. 5—Amount of induced torque in the shank of the bolt is about 45 percent of the torque applied with a torque wrench.

its axis. The remaining 90 percent is divided almost equally between overcoming frictional torque resistance between the plate and the nut and between the nut threads and bolt threads. These relationships can be derived from the curves in Figs. 5 and 6, or deduced from the strain gage torque readings. The torque in the bolt as measured by the SR—4 gages is approximately 45 percent of the torque applied. This torque must be balanced by frictional resistance of the nut and plate, thus leaving 10 percent of the applied energy to be absorbed in tension.

Each different bolt diameter will show this same relationship. The induced torque-resisting moment developed in the shank of the bolt will be about 45 percent of the total applied torque-wrench effort in foot-pounds. This induced torque in the bolt cannot exceed the torque resisting moment developed by the friction between the base of the nut and the outside plate surface because it is this frictional

torque that holds the torque on the bolt. A typical test run illustrated in Fig. 5 shows the relationship of applied torque to clamping force and total induced torque.

Bolt Failure

The set-up in Fig. 4 illustrates the method of loading the bolt where only the applied torque and clamping force is measured. The fixture is arranged so that a bolt assembled on it will exert force on the testing machine, which will be measured on the machine dial. The machine does not pull the specimen.

The opinion most commonly held is that the bolt is twisted off in a simple torsional shear failure. It is evident that there is a shearing stress in the bolt caused by the torque, which is applied by friction between the threads of the bolt and the nut as the nut is turned. The combined mechanical advantages of wrench leverage and thread incline, result in an axial or clamping force, on the bolt that causes primary tensile components. These components dominate in the failure process. When the axial stretch of the threaded section of the bolt approaches its ultimate value, the threads of the bolt no longer fit the threads of the stretched bolt. Tremendous friction develops between the nut and the bolt—enough to freeze the nut in place so that the bolt will twist off if the twisting process is carried far enough. Data in Fig. 6 and Table I are obtained from this phase of the tests.

The principal effect of the shearing stress is to reduce the tensile stress at failure to a value averaging about 80 percent of the strength of the bolt in direct tension.

The torque-tension curves for a series of the bolts tested are shown in Fig. 6. Table I gives the controlling strength values of the same sizes of bolts. The 80 percent ratio of tensile stress at failure in torquing to ultimate stress is obtained from the clamping force of the bolt at failure in the torque-tension test and the corresponding Rockwell test, which indicates the ultimate tensile stress. Tests of all of the sizes between ¼ in. and 1 in. dia, both coarse and fine thread, showed an average 80 percent relationship to hold. Furthermore, this same relationship holds for the yield strength under torquing, which is proportionally reduced to about 80 per cent of pure tension yield strength.

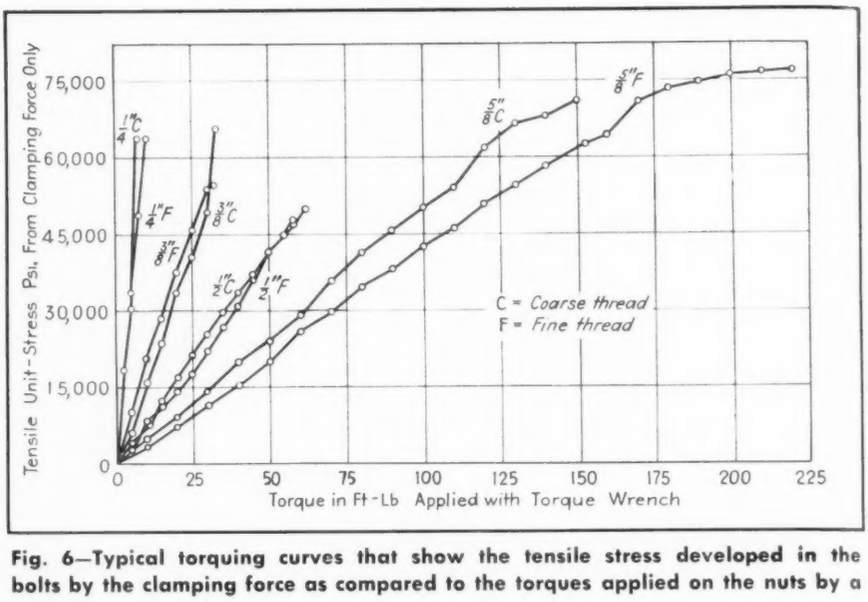


Fig. 6—Typical torquing curves that show the tensile stress developed in the bolts by the clamping force as compared to the torques applied on the nuts by a wrench.

Table I—Showing Controlling Strength Values of Bolts Tested in This Investigation

Bolt Size	¼" F	¼" C	⅜" F	⅜" C	½" F	½" C	⅝" F	⅝" C
Torque at Failure (ft-lb)	10	7.5	32	33	62	58	200	150
Total Clamping Force at Failure (Measured) (lb)	2,355	2,025	4,785	5,055	7,980	6,760	19,360	16,000
Tensile Unit Stress at Ultimate (psi)	64,900	64,000	54,600	65,600	50,000	47,800	75,700	71,000
Ultimate Tensile Stress by Rockwell Hardness (psi)	80,000	70,000	66,000	82,000	59,000	71,000	99,000	92,000
Percentage Ratio of Tensile Direct Ultimate Unit Stress to Rockwell Hardness Indication	81	91	83	80	85	67	77	77
Computed Torsional Stress Using 45 percent Applied Torque (psi)	27,200	25,550	23,700	29,240	18,600	20,950	29,600	26,800
Principal Strain Theory Maximum Combined Principal Stress or Tension (psi)	77,600	75,600	65,600	80,100	57,900	57,950	88,900	82,600
Principal Stress Theory Maximum Combined Principal Stress or Tension (psi)	74,800	72,850	63,450	76,650	55,900	55,100	85,850	80,500

Determining Bolt Tension

There are several methods of determining the bolt tension developed in torquing. The simplest, though not the most precise, is to estimate the tension from the amount of torque applied with a torque wrench. The results indicate that it is practical to control bolt tension by the control of nut torque, that the tension developed can be predicted from the applied torque, and that the accuracy of the prediction is within practical limits for many applications.

Besides the torque-tension tests to

Table II—Bolt Stress Induced by Nut Tightening for High-Point Torque

Size	No. of samples	Torque ft-lb	Stress average psi*	Deviation of stress from average, percent		
				Max	Min	Avg
1/ 4–20	15	7	43,270	11.2	14.7	4.1
1/ 4–28	20	7	42,405	19.6	17.5	5.6
5/16–18	20	12	42,825	28.5	32.8	11.3
5/16–24	20	12	41,010	14.3	20.8	1.5
3/ 8–16	25	25	51,760	21.4	24.6	6.6
3/ 8–24	15	25	47,500	15.8	25.1	6.9
7/16–14	20	40	47,613	14.8	10.9	6.4
7/16–20	20	40	47,890	24.1	22.3	9.2
1/ 2–13	20	55	45,300	19.6	30.5	11.4
1/ 2–20	20	55	45,000	21.6	21.6	7.5
9/16–12	15	80	48,360	11.7	10.1	2.5
9/16–18	20	80	42,968	22.9	26.5	6.9
5/ 8–11	24	110	52,400	15.3	27.2	7.3
5/ 8–18	18	150	61,500	23.6	23.6	10.5
3/ 4–10	19	180	50,800	12.2	15.7	2.5
3/ 4–16	19	160	40,300	20.6	16.6	7.0
7/ 8–9	15	260	42,643	29.7	22.8	10.0
7/ 8–14	10	260	40,920	15.9	15.4	9.1
1–8	10	380	40,182	8.3	10.4	2.8
1–14	10	400	44,070	11.2	12.0	1.9

* Based on mean area of threaded section; area at the mean of the root and pitch diameters.

Table III—Bolt Stress Induced by Nut Tightening for Mid-Point Torque

Size	No of samples	Torque ft-lb	Stress average psi*	Deviation of stress from average, percent		
				Max	Min	Avg
1/ 4–20	15	4	22,642	21.9	29.6	3.0
1/ 4–28	20	4	22,820	23.6	20.7	6.1
5/16–18	20	5	19,600	22.2	34.0	13.5
5/16–24	20	5	18,176	22.7	29.0	5.8
3/ 8–16	25	15	31,400	20.7	17.5	5.1
3/ 8–24	15	15	29,270	16.3	22.8	7.5
7/16–14	20	20	23,062	20.9	23.5	10.3
7/16–20	20	20	24,420	19.2	16.9	2.5
1/ 2–13	20	25	19,525	24.5	30.3	11.8
1/ 2–20	20	25	18,230	19.9	16.2	3.7
9/16–12	15	40	21,893	13.3	14.6	0.6
9/16–18	20	40	20,355	16.4	20.0	4.5
5/ 8–11	24	55	23,860	22.4	36.3	10.6
5/ 8–18	18	75	32,100	10.0	15.0	2.9
3/ 4–10	19	100	27,800	20.8	16.2	7.3
3/ 4–16	19	80	19,100	22.5	24.1	4.1
7/ 8–9	15	140	21,411	25.2	32.7	13.8
7/ 8–14	10	140	21,255	12.0	18.6	7.6
1–8	10	180	17,478	11.0	13.1	2.1
1–14	10	200	21,214	13.1	11.8	2.1

* Based on mean area of threaded section; area at the mean of the root and pitch diameters

failure, many bolts of the same size were tested at a high-point and mid-point torque as estimated from the complete curve. These values were derived from the complete torque-tension curve; the high-point torque being just below the yield point of the material with the mid-point torque being half this value. For each bolt a new nut and washer was used. Tables II and III show the number of samples, the torque, the stress based on the mean area of the threaded section, and the percent deviation.

The Torque Coefficient

From this test data a torque coefficient, R, has been computed. The relation between torque and tension is then expressed by the formula: Torque lb — in.) $= R \times$ bolt dia (in.) $\times$ clamping force (lb)

The theoretical value of the torque coefficient is approximately constant regardless of the size of the bolt and threads per inch. It varies between 0.188 and 0.210 if a coefficient of friction of 0.15 is assumed for the bearing surfaces of the nut face and threads. Table IV gives the torque coefficients for each size of bolt as to theoretical, high-point torque, and mid-point torque values. These are average values only and the deviations of Tables II and III hold.

This data shows that to apply any clamping force desired up to 80 percent of the yield strength the approximate governing formula is:

Torque (1 lb — in.) $=0.2 \times$ bolt dia (in.) $\times$ clamping force (lb) for any size of bolt.

The clamping force calculated for the torque applied by the usual torque wrench may vary from the average as much as 30 percent; but the average deviation will be of the order of 6-7 percent. The tests also reveal that the torque-tension relationship for a bolt is a straight line function up to the yield point of the bolt material.

Table IV—Torque Coefficients

Bolt Size	*Theoretical	Torque Coefficients—R Measured (average)	
	R	High-point torque	Mid-point torque
1/ 4–20	0.210	0.243	0.267
1/ 4–28	0.205	0.216	0.231
5/16–18	0.210	0.206	0.186
5/16–24	0.205	0.194	0.183
3/ 8–16	0.204	0.200	0.247
3/ 8–24	0.198	0.192	0.234
7/16–14	0.205	0.217	0.224
7/16–20	0.200	0.194	0.190
1/ 2–13	0.201	0.205	0.158
1/ 2–20	0.195	0.167	0.205
9/16–12	0.198	0.194	0.214
9/16–18	0.193	0.196	0.207
5/ 8–11	0.199	0.178	0.196
5/ 8–18	0.193	0.183	0.175
3/ 4–10	0.194	0.169	0.172
3/ 4–16	0.189	0.170	0.180
7/ 8–9	0.194	0.181	0.194
7/ 8–14	0.189	0.171	0.178
1–8	0.193	0.188	0.204
1–14	0.188	0.161	0.167
Average	0.198	0.191	0.201

* Computed with coefficient of friction of 0.15 and the dimensions of American Standard Regular Nuts.

External Friction Blocks and Shoes

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Consulting Engineer

Conditions that make external contracting shoes self-energizing and self-locking are discussed along with recommendations on positioning the hinge pin, choosing dimensions and selecting linings to embody self-energization and self-locking into the design of brakes.

EXTERNAL friction blocks and shoes are analyzed in practically the same way as friction shoes of the internal type. (See an article on "Internal Friction Blocks and Shoes" in the March 1947 Number of PRODUCT ENGINEERING, pages 133-38.) One principal difference between an internal shoe and an external shoe is that with an internal shoe self-energization always occurs with the construction ordinarily used, but with an external shoe, particular attention must be paid to positioning the hinge pin to obtain self-energization of any appreciable amount. Let

T = applied or actuating force;
μ = coefficient of friction;
R = total normal pressure between friction surfaces;
μR = frictional resistance to sliding between the friction surfaces;
P_1 = vertical component of pin reaction as shown in Fig. 1;
P_2 = horizontal component of pin reaction;
E = ratio of self-energization;
p_a = normal unit pressure at point of maximum pressure;
p = normal unit pressure at point (1) in Fig. 1;
r = radius of shoe surface;
b = width of friction surface;
a = distance of hinge pin from center;
θ_1 = angular length of shoe from hinge point;
θ_2 = angular length of heel relief;
θ_a = Angular distance to point of maximum pressure; and
θ_o = angular distance to center of pressure.

ASSUMPTION. Suppose the intensity of normal pressure against the drum is proportional to the distance of the extended normal line from the hinge pin. In accordance with this assumption, the unit pressure is not uniform over all the surface. It is maximum at some point and zero at the heel point or under the hinge pin. As with the internal shoe, the heel point or hinge point is the point on the friction surface intersected by a radial line from the center of rotation to the hinge pin. Further, since the greatest distance from the hinge pin to a normal to the friction surface is a, Fig. 1, when θ_1 is equal to or greater than 90 deg., therefore the maximum pressure is at 90 deg. from the hinge pin. Then in accordance with the assumption

$$\frac{p}{a \sin \alpha} = \frac{p_a}{a \sin \theta_a} \tag{1}$$

or

$$p = p_a \sin \alpha / \sin \theta_a \tag{2}$$

The total normal pressure is found by integration. Since

$$\Delta R = p\, br\, \Delta\alpha = p_a\, br \sin\alpha\, \Delta\alpha / \sin \theta_a \tag{3}$$

integration between the limits θ_2 and θ_1 gives

$$R = p_a br\, (\cos \theta_2 - \cos \theta_1)/\sin \theta_a \tag{4}$$

The moment of ΔR is

$$\Delta M = p_a abr \sin^2\alpha\, \Delta\alpha / \sin \theta_a \tag{5}$$

so that integration between the limits θ_2 and θ_1 gives

$$M = \frac{p_a abr}{\sin \theta_a} \frac{(2\theta_1 - \sin 2\theta_1) - (2\theta_2 - \sin 2\theta_2)}{4} \tag{6}$$

If the center of pressure is represented by the distance y_o, then

$$y_o = a \sin \theta_o = M/R = a \frac{[(2\theta_1 - \sin 2\theta_1) - (2\theta_2 - \sin 2\theta_2)]}{4\,(\cos \theta_2 - \cos \theta_1)} \tag{7}$$

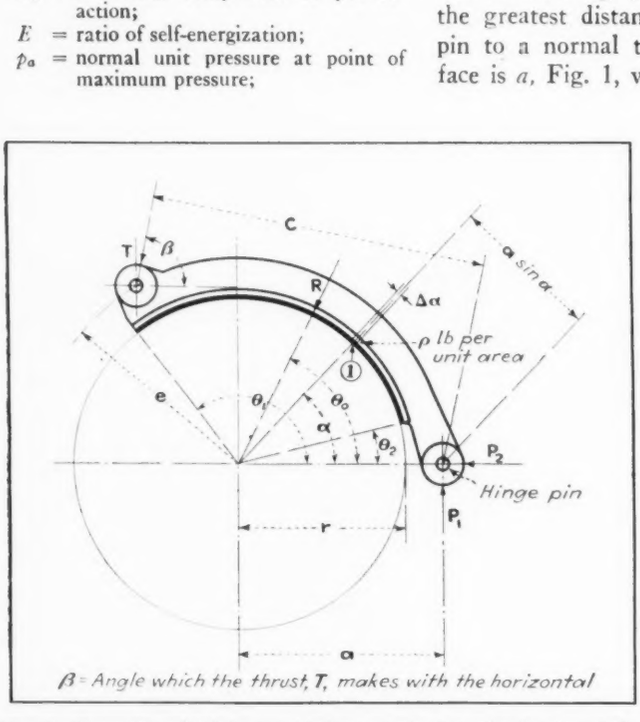


Fig. 1—Force *T*, which is applied at angle β to the horizontal, pivots about hinge pin in pressing shoe against the drum.

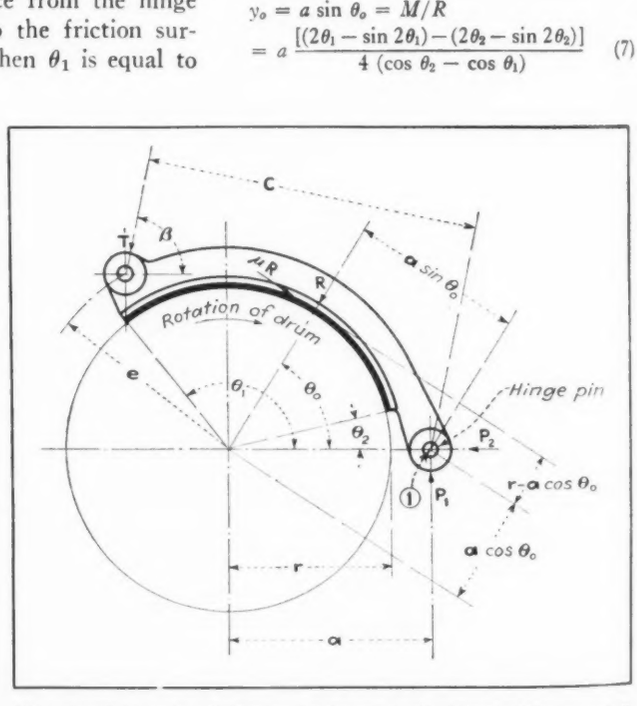


Fig. 2—Moments of forces *T*, *R* and μR about hinge establish moment equation. Hinge location determines ratio *E*.

To simplify calculations, values of $(2\theta - \sin 2\theta)/4$ have been computed and arranged in tabular form. They are called I values. For instance, see Table 1, p. 136, March 1947 Number of PRODUCT ENGINEERING.

In all practical designs, the friction lining is not carried back to the hinge point, being stopped some distance from the hinge point to provide heel clearance. With internal friction shoes, the heel clearance is usually rather small and consequently θ_2 can be ignored in the calculations without introducing any appreciable error. Likewise with an external shoe, the angle θ_2 can be ignored in most calculations. If the heel angle is roughly $\frac{1}{8}$ the full angular length of the shoe, θ_1, the error will be about 2 percent. With θ_2 not considered, the pertinent equations are

$$R = p_a br\,(1 - \cos\theta_1)/\sin\theta_a \qquad (8)$$

$$\sin\theta_o = \frac{2\theta_1 - \sin 2\theta_1}{4\,(1 - \cos\theta_1)} \qquad (9)$$

Actuating Means and Resultant Forces

Various means are used to actuate shoes, no special or particular arrangements being discussed here. In Fig. 2, there is shown only the position of the connection point on the actuating device and the direction of the line of force with respect to the hinge point. With rotation of the drum in a clockwise direction as shown by the arrow, moments about point (1) gives

$$Tc = R\,[a\,(\sin\theta_o + \mu\cos\theta_o) - \mu r] \qquad (10)$$

The function, $(\sin\theta_o + \theta_o)$, is designated as k. Values of k are given in Table II, p. 138, March 1947 PRODUCT ENGINEERING. They are shown graphically in Fig. 3 along with similar functions that are defined as g, h, and i values. Thus Equation (10) can be written simply as

$$Tc = R\,(a\,k - \mu r) \qquad (11)$$

Reactions against the hinge pin are found by inspection as

$$P_1 = Rk - T\sin\beta, \text{ and} \qquad (12)$$

$$P_2 = T\cos\beta - Rh \qquad (13)$$

Since self-energization is not as great with this type of shoe as with the internal shoe, particular effort must be made to position the hinge pin properly to secure the maximum self-energization. After the equation for self-energization is developed, it will be studied in order to suggest ways in which self-energization can be increased. As stated in the previous article on internal shoes, the ratio of self-energization, E, is found by comparing the torque, Tc, required to produce a given value of R when no rotation occurs with the torque required to produce the same value of R with rotation.

Let $(Tc)_o$ be the torque with no rotation. Then

$$(Tc)_o = Ra\sin\theta_o \qquad (14)$$

From Equations (11) and (14)

$$E = (Tc)_o/Tc = \frac{\sin\theta_o}{k - \mu r/a} \qquad (15)$$

As inspection of Equation (15) shows that E increases as $\sin\theta_o$ increases. Differentiating Equation (9) with respect to θ_1 and equating to zero, $\sin\theta_o$ is found to be maximum when θ_1 is 122 deg 34 min closely. Therefore θ_1 should be nearly of equal magnitude for maximum E. The value of k in the denominator is also maximum when θ_1 is 122 deg 34 min. Consequently the value of $\mu r/a$ should be as large as possible in order to reduce the denominator to the lowest value. Therefore the only variable subject to change is a which should be made as small as possible so as to make $\mu r/a$ as large as possible. It follows that the hinge pin should be held as close to the drum as the construction will permit to obtain a large value of $\mu r/a$. If the proportions are such that the denominator is zero, E becomes infinite, which means that the shoe would be self-locking. It is advisable therefore to keep the value of $\mu r/a$ enough less than k to avoid locking should a replacement lining be used with a higher friction coefficient. Should $\mu r/a$ be too nearly equal to k, grabbing action may result. The conclusion is that maximum self-energization is obtained by making the shoe angle θ_1, as near $122\frac{1}{2}$ deg as possible and placing the hinge pin as near the drum surface as possible.

Frequently two external shoes are used as a brake on an electric hoist. One shoe functions with clockwise rotation, the equations for which have just been given. The other shoe functions with counterclockwise rotation of the drum, or in the direction opposite to that shown by the arrow in Fig. 2, for which the following equations apply.

$$Tc = R\,[a\,(\sin\theta_o - u\cos\theta_o) + \mu r] = R\,(ai + \mu r) \qquad (16)$$

Reactions against the pivot are:

$$P_1 = Ri - T\sin\beta, \text{ and} \qquad (17)$$

$$P_2 = T\cos\beta - Rg \qquad (18)$$

Self-energization is determined by the quotient of

$$(Tc)_o = Ra\sin\theta_o \qquad (19)$$

and Equation (16), or

$$E = \frac{\sin\theta_o}{i + \mu r/a} \qquad (20)$$

From which it is readily seen that self-locking cannot occur with counter clockwise rotation as the denominator cannot be reduced to zero.

The friction of contact between the driving and the driven members

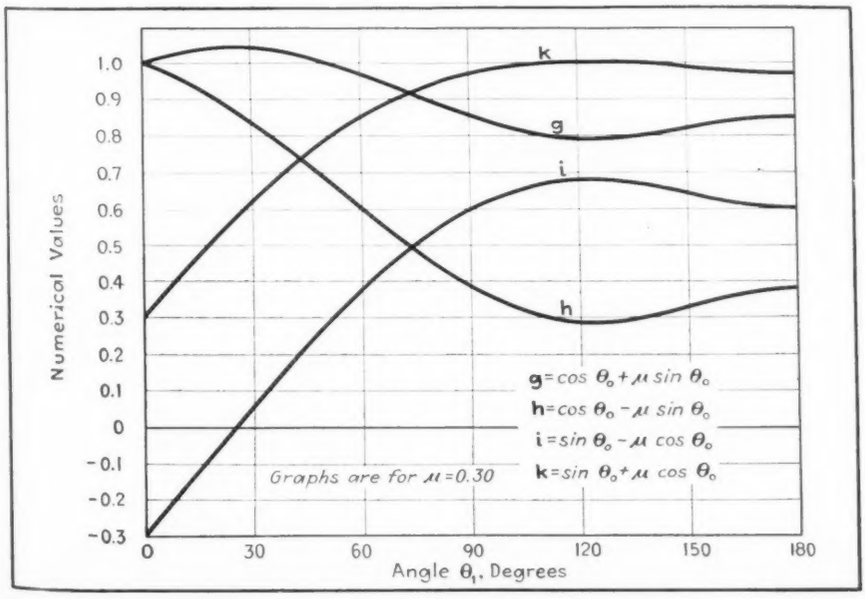


Fig. 3—Values of *g*, *h*, *i* and *k* for a coefficient of friction μ of 0.30 can be taken from curves. *G*, *h*, *i* and *k* are trigonometric functions used in equations.

Table I—Values of R_z* sin θ_o and θ_o for intervals of 5 Degrees

θ_1 deg	R_z*	†For θ_2 = zero: sin θ_o	θ_o deg	θ_o min	θ_2 deg	θ_2 min	†With θ_2 reducing R_z by 2 percent: sin θ_2	R_z*	sin θ_o	θ_o deg	θ_o min
5	0.0437	0.05813	3	20	0	42	0.01234	0.0428	0.05915	3	23
10	0.0875	0.11594	6	40	1	25	0.02465	0.0857	0.11798	6	47
15	0.1317	0.17314	9	58	2	7	0.03692	0.1290	0.17473	10	4
20	0.1763	0.22942	13	16	2	49	0.04910	0.1728	0.23344	13	30
25	0.2217	0.28450	16	32	3	30	0.06119	0.2173	0.28947	16	50
30	0.2679	0.33807	19	46	4	12	0.07316	0.2626	0.34398	20	7
35	0.3153	0.38988	22	57	4	52	0.08498	0.3090	0.39667	23	22
40	0.3640	0.43967	26	5	5	33	0.09662	0.3567	0.44733	26	34
45	0.4142	0.48721	29	9	6	12	0.10808	0.4059	0.49568	29	43
50	0.4663	0.53226	32	10	6	51	0.11932	0.4570	0.51450	32	47
55	0.5206	0.57465	35	5	7	29	0.13032	0.5102	0.58460	35	46
60	0.5774	0.61418	37	54	8	7	0.14107	0.5658	0.62480	38	40
65	0.6371	0.65073	40	36	8	43	0.15153	0.6243	0.66195	41	27
70	0.7002	0.68417	43	10	9	18	0.16170	0.6862	0.69631	44	8
75	0.7673	0.71440	45	36	9	53	0.17154	0.7520	0.72664	46	36
80	0.8391	0.74136	47	51	10	26	0.18105	0.8223	0.75403	48	56
85	0.9163	0.76503	49	55	10	58	0.19021	0.8980	0.77787	51	4
90	1.0000	0.78540	51	46	11	29	0.19900	0.9800	0.79871	53	0
95	1.0872	0.80250	53	22	11	58	0.20739	1.0654	0.81605	54	41
100	1.1736	0.81640	54	44	12	26	0.21539	1.1502	0.82062	55	9
105	1.2588	0.82720	55	49	12	53	0.22298	1.2336	0.84104	57	15
110	1.3420	0.83503	56	37	13	18	0.23013	1.3152	0.84893	58	6
115	1.4226	0.84005	57	9	13	42	0.23684	1.3942	0.85397	58	39
120	1.5000	0.84247	57	24	14	4	0.24311	1.4700	0.85634	58	55
125	1.5736	0.84251	57	24	14	25	0.24890	1.5421	0.85631	58	54
130	1.6428	0.84044	57	11	14	44	0.25423	1.6099	0.85412	58	40
135	1.7071	0.83656	56	47	15	1	0.25907	1.6730	0.85010	58	13
140	1.7660	0.83120	56	13	15	16	0.26343	1.7307	0.84456	57	38
145	1.8192	0.82472	55	34	15	30	0.26729	1.7828	0.83790	56	55
150	1.8660	0.81751	54	50	15	42	0.27064	1.8287	0.83050	56	9
155	1.9063	0.81002	54	6	15	52	0.27349	1.8682	0.82281	55	22
160	1.9397	0.80268	53	23	16	1	0.27583	1.9009	0.81530	54	37
165	1.9659	0.79601	52	45	16	7	0.27765	1.9266	0.80846	53	57
170	1.9848	0.79052	52	14	16	12	0.27896	1.9451	0.80284	53	24
175	1.9962	0.78678	51	53	16	15	0.27974	1.9563	0.79902	53	2
180	2.0000	0.78540	51	46	16	16	0.28000	1.9600	0.79760	52	54

†With θ_1 less than 90 deg., θ_a equals θ_1 but with θ_1 of 90 deg. or more θ_a is 90 deg.
*$R_z = R/p_a br$

is μR. With n as the number of shoes, all equally actuated, the coupling torque is,

$$Y = n\mu Rr \text{ lb.-in.} \qquad (21)$$

The use of Table I will be found convenient in finding out when the angle of relief, θ_2, can be ignored in the calculations without introducing an error of more than 2 percent. Values of θ_2 corresponding to values of R_z reduced by 2 percent are also included.

EXAMPLE. Determine the braking capacity of a double shoe mechanism shown by Fig. 4. The drum is 16 in. in diameter and has shoes 3 in. wide. The shoes are identical with θ_1 of 129 deg 5 min and θ_2 of 9 deg 5 min. The lining pressure is limited to 150 lb per sq in. and μ is taken as 0.30. The value of θ_2 is ignored in the calculations as the resulting error is less than 2 percent.

Since θ_1 is greater than 90 deg., sin θ_a is unity. Upon substituting known numerical quantities into Equation (8)

$$R = p_a br\,(1 - \cos\theta_1)/\sin\theta_a$$
$$= 150 \times 3 \times 8\,(1 + 0.6305)/1$$
$$= 5{,}870 \text{ lb}$$

The I value corresponding to this value of θ_1 is 1.3711, which can be computed or obtained from tabular values of a previous article.

$$\sin\theta_o = \frac{I}{1 - \cos\theta_1}$$
$$= \frac{1.3711}{1.6305} = 0.8409$$

Therefore θ_o is 57 deg 14 min and cos θ_o is 0.5412. Although k could be taken from the Fig. 3, it is calculated as follows:

$$k = \sin\theta_o + \mu\cos\theta_o$$
$$= 0.8409 + 0.3 \times 0.5412 = 1.0033$$

From Equation (11)

$$T = R\,(ak - \mu r)/c$$
$$= 5{,}870\,(9 \times 1.0033 - 0.3 \times 8)/17.657$$
$$= 2{,}204 \text{ lb}$$

As this same force actuates the other shoe, the value of R resulting from the applied force on the second shoe is found from Equation (16); namely,

$$R = Tc/(ai + \mu r)$$
$$= \frac{2{,}204 \times 17.657}{9 \times 0.6785 + 0.3 \times 8}$$
$$= 4{,}575 \text{ lb}$$

The braking torque is found from the coupling torque equation, or

$$Y = n\mu Rr$$

Since the shoes are identical excepting for different values of R, the sum of the two values of R is used in this equation with an n of unity.

$$\text{Total } R = 5{,}870 + 4{,}575$$
$$= 10{,}445 \text{ lb and}$$
$$Y = 1 \times 0.30 \times 10{,}445 \times 8$$
$$= 25{,}068 \text{ lb-in.}$$

The foregoing value of Y can be checked by finding the moment of the total reaction. This can be done since the actuating forces on the two shoes balance each other. The P_1 for the first shoe is,

$$P_1 = Rk - T\sin\beta$$
$$= 5{,}870 \times 1.0033 - 2{,}204 \times 0.9341$$
$$\times 3{,}830 \text{ lb}$$

P_1 for the second shoe is:

$$P_1 = Ri - T\sin\beta$$
$$= 4{,}575 \times 0.6785 - 2204 \times 0.9341$$
$$= 1{,}045 \text{ lb}$$

Therefore the resulting torque is,

$$P_1a \text{ (for first shoe)} - P_1a \text{ (for second shoe)}$$
$$= (3{,}830 - 1{,}045)\,9$$
$$= 25{,}065 \text{ lb-in.}$$

which checks the value, 25,068 lb-in. previously obtained.

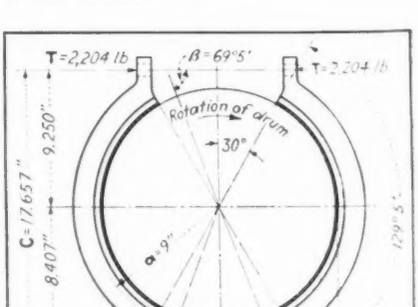
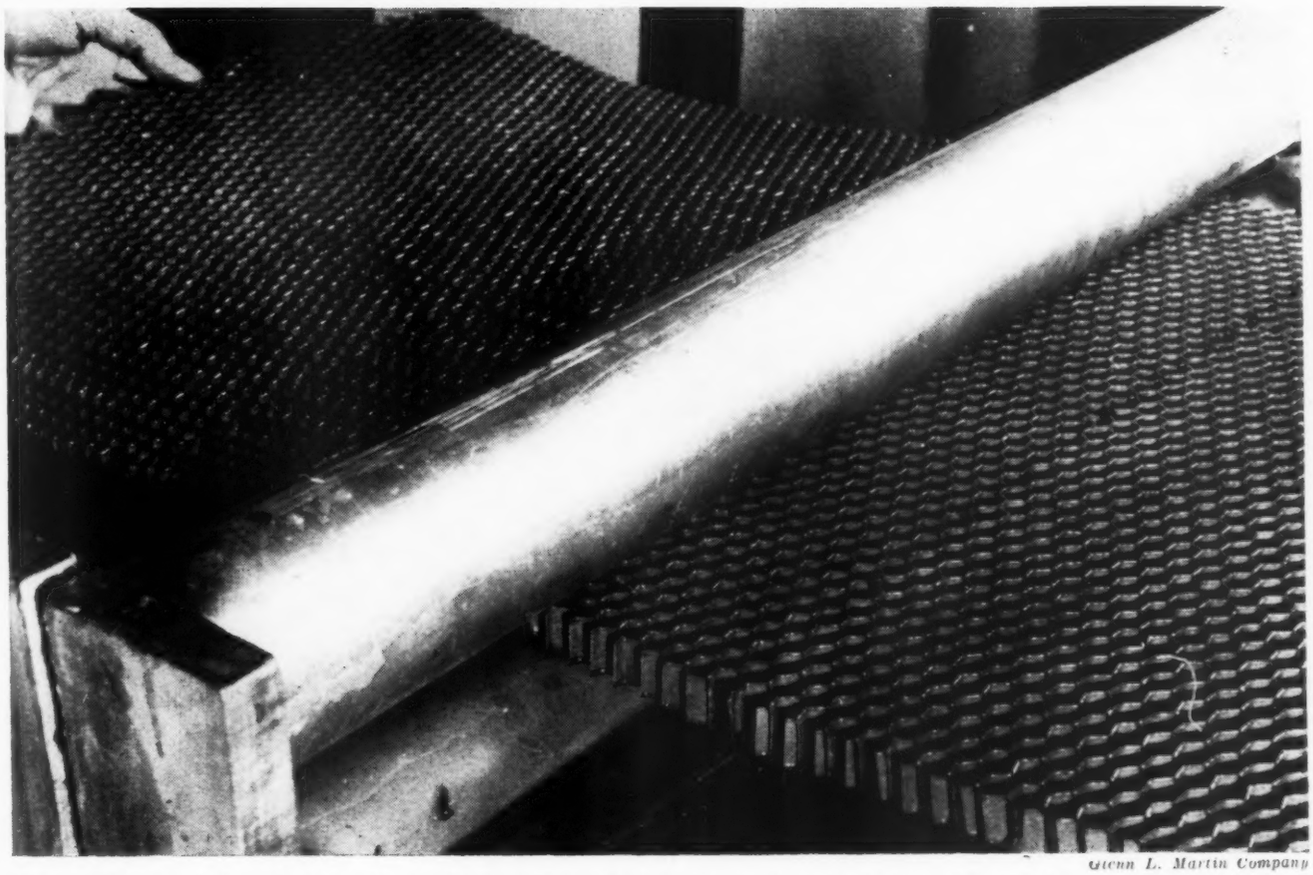


Fig. 4—Two shoe brake defining dimensions to accompany the solution of numerical example on this page.



Glenn L. Martin Company

Honeycomb core being coated with synthetic resin adhesive, preparatory to facing with wood or metal sheets. Such sandwich structures, including those with expanded plastic cores, are used in the aircraft and refrigerating industries.

Industrial Adhesives—II

NICHOLAS J. DE LOLLIS
National Bureau of Standards

Properties and uses of thermosetting resin adhesives. Applications of all types of adhesives in wood, metal-to-wood, metal-to-metal, metal-to-glass, and plastic and rubber bonding.

ADHESIVES based on thermosetting resins usually come in two parts —the partially cured resin, and a hardening agent or catalyst which is added to the resin at the time of use, to complete the cure. They are divided into three classes, depending on the temperature required for the final cure:

Class R: Resins that cure at or near room temperature (up to 86 F.)

Class M: Resins that cure at a slightly elevated temperature, not over 211 F.

Class H: Resins that cure at a relatively high temperature, greater than 211 F.

The urea, melamine, phenolic and furfural resins can be prepared so that they fit into each of the three thermosetting classifications. This is done by varying the acid or alkali concentration in the agent or catalyst used to complete the cure of the resin. In using acid or alkali, the finished job must be considered. Too strong a concentration of either will result in a weakened bond. Where maximum bond strength is desired, acid or alkali concentration should be kept to a minimum.

Urea-formaldehyde adhesives are lower in cost than the phenol-formaldehyde types. They are light in color and have good heat resistant properties up to about 160 F. They are less resistant to chemical agents, elevated temperatures, and weathering than are the phenolics, but when properly used they give equally good service.

Unfilled urea-formaldehyde resins are extremely brittle and tend to craze. These defects may be completely overcome by using the proper filler, usually some form of cellulose. As an additional safeguard, thick glue lines should be avoided by making all joints as close fitting as possible. The urea resins are used chiefly in the woodworking industry, and are replacing casein in plywood manufacture. They are marketed either as water soluble powders, with the curing agent either separate or combined,

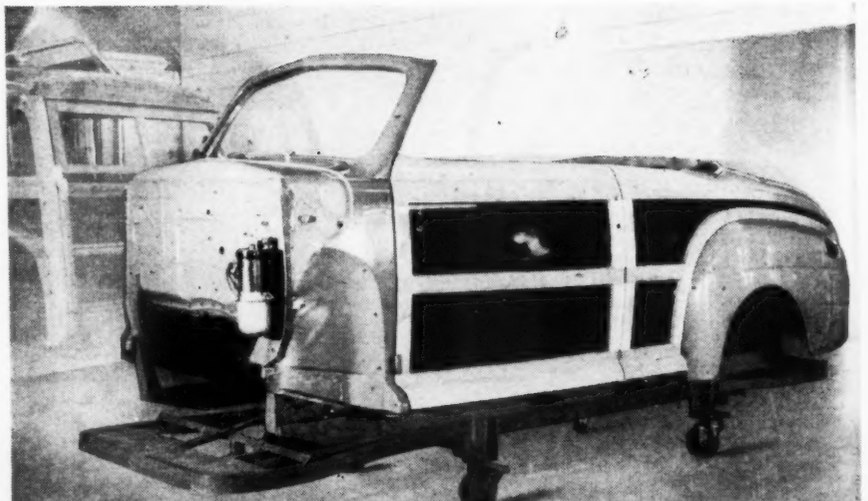
or as syrupy water solutions with separate curing agents.

The melamines are similar to the ureas in color and use but are stronger and have a higher resistance to moisture, boiling water, and attack by acids. They are higher in cost and are replacing the ureas where better performance makes replacement desirable.

Many new applications of urea and melamine adhesives have been adopted, including prefabricated houses, station wagon bodies, furniture, and curved molded plywood. The Ford Motor Company has adopted a urea formaldehyde adhesive for assembly work in their station wagons and new "Sportsman" convertible. They have found that the water resistant bond makes for a better, longer lasting wooden body. This adhesive can be used successfully where perfect fitting of parts is not always possible. Important production savings have also been realized because the resin does not require much pressure to affect cure.

The phenol formaldehyde resins are the most widely used and most important resins. They have extreme resistance to water, weathering, temperature variations, and chemical and bacterial action. Thus, a phenol-formaldehyde bond is the strongest part of a wood assembly. Curing temperatures for phenol-formaldehyde resins range from 300 F for the neutral state to 70 F for varying concentrations of alkali or acid. Temperatures above 300 F are harmful to wood. Glues setting at lower temperatures are not often used because of the deteriorating effect of the catalysts on the wood. Therefore, the phenolic glues are used mainly in primary gluing—in plywood production where heat can be applied conveniently. In secondary gluing, principally in large assemblies, where heat cannot be as readily applied, phenolics are seldom used.

Phenolic adhesive resins are supplied in three forms—film, powder and liquid. The film form consists of a thin coating of the resin, partially cured, and spread and dried on both sides of an extremely thin paper. This film is placed between wood veneers, and heat and pressure are applied. This softens the resin, causing it to adhere to the wood and completes the cure. The powder form is mixed with water, alcohol, acetoneor combinations of the three. This and the liquid form are applied by spreading mechanisms, usually corrugated rubber rollers.



American Cyanamid Company

New Ford "Sportsman" convertible is assembled with urea resin adhesive, which gives a water-resistant bond. Center pieces of component parts are cut from maple blocks; flat panels are constructed of gum or mahogany plywood.

Baking type liquid phenolic cements have been developed for special uses, such as "potting" compounds. An example is the molded plastic insulators permanently fastened to metal cans, to serve as radio condensers. The cement must be applied in a thin layer —not more than ¼ in.—over the molded part.

Air-drying, cold setting, and low temperature baking cements also find application for general bonding requirements. One air-drying type, containing rubber in its formulation, is suitable only for service under 150 deg. F. It is affected by gasoline, benzol, and other hydrocarbon solvents. Where these conditions are present the baking cements are recommended. Another cold-setting type, developed primarily for plywood bonding, is useful for other applications wherever a permanent, non-acid glue that sets at room temperature is demanded.

Resorcinol-formaldehyde resins are chemically related to the phenolics. They are similar in resistance to deteriorating conditions. They are unique, however, in their ability to cure at room temperature. Their high cost limits them to uses where cost is secondary, such as the aircraft and boat building industries. Resorcinol-formaldehyde adhesives are supplied in liquid form with a separate curing agent.

Furfuryl alcohol produces resins which bond a wide variety of materials and is especially recommended for thermosetting plastics. Its acidity makes it suitable for bonding wood and other acid-vulnerable materials.

The monomer, or unpolymerized form, of the allyl family of resins cures to a water clear, partially thermoplastic, insoluble material. As an

adhesive it is used to impregnate fibrous materials to form laminates. An allyl resin has been developed to replace Canada balsam as an optical cement. Used in thin sections, this resin has superior optical qualities, and gives excellent adhesion to glass. Weathering properties are also superior.

The unsaturated polyesters exist in great variety, and their properties vary from a rubbery resin to a hard brittle state. All form clear yellow resins, and like the allyl resins, require a peroxide catalyst. Their main use as adhesives is in the manufacturer of glass cloth laminates.

Combinations of some of these resins are used to produce compounds with intermediate properties. Thus, urea is sometimes combined with either a phenolic or a melamine resin. This improves the properties of the urea glue without much added cost.

Rubber-Base Adhesives

Rubber is characterized by its great flexibility and ability to absorb shocks. In solution it has the properties of a "perfect" adhesive, bonding to practically any type of surface. The drawbacks inherent in rubber cements are the low solids content of the solutions, low cohesive strength in the unvulcanized state and the unwieldy products that is formed. In the vulcanized state, the cohesive strength is greater than the adhesive strength. Rubber emulsified in an aqueous medium can have a solids content as high as 60 to 75 percent and still not be too viscous.

Natural rubber has the best all around adhesive ability but it is less resistant than the synthetic rubbers to organic solvents, heat, chemical action, and atmospheric oxidation. Its greatest use is in the shoe industry. The automobile industry uses it extensively to bond felt, cloth and rubber stripping to metals. Also, it is sold widely as a household cement.

Reclaimed rubber does not have the universal application of natural rubber, but is used as a general utility cement. It retains the poor stability of natural rubber.

Polysulfide rubber, or "Thiokol," is a specialty product, which has relatively low tensile strength and elastic properties but it is practically unaffected by organic greases, oils and solvents. It shows excellent resistance to aging and low permeability to gases. Because of these properties, it is used almost exclusively in applications where oil and solvent resistance are required.

Neoprene probably has the most general application of the synthetic rubbers. As an adhesive, its elasticity and tensile strength compares well with natural rubber, which it excels in resistance to organic solvents, heat, sunlight, chemical action and atmospheric oxidation. Adhesives made from certain modified GR-S materials have been found to be comparable to the reclaimed rubber adhesive Butadiene-styrene copolymers having high styrene content give adhesives with high tensile strength. Butadiene-acrylonitrile copolymer adhesives have good resistance to oils and fuels. Because of its tendency to flow under deformation, butyl rubber adhesives must be especially compounded.

All of the Buna type rubbers lack the property of welding readily to themselves. This means that bonds must be made while considerable solvent is present. Properly compounded, however, they give tensile values almost double those of reclaimed rubber-base adhesives.

The new phenolic-elastomer adhesives are the most interesting group. They combine the strength and adhesive properties of the phenolic resins with the flexibility and resilience of rubber. They also retain the characteristic phenolic resistance to corroding conditions. The development of this group resulted from the de-

Selection of Resin Adhesives for Plywood and Assembly Gluing

Type of Resin Adhesive	Exterior Grade Highest Durability Plywood		High Moisture-Resistant Plywood		Medium to Low Moisture-Resistant Interior Grade General Purpose Plywood	
	Plywood	Assembly	Plywood	Assembly	Plywood	Assembly
Urea—Formaldehyde			x	x	x	x
Urea—Formaldehyde, low flour extender			x		x	
Urea—Formaldehyde, high flour extender					x	
Melamine Formaldehyde	x		*			
Melamine—Urea—Formaldehyde	x		*			
Phenol Formaldehyde			*			
Resorcinol Formaldehyde	*	x	*	x	x	*

* Gives good bond, but is costly.

American Cyanamid Company

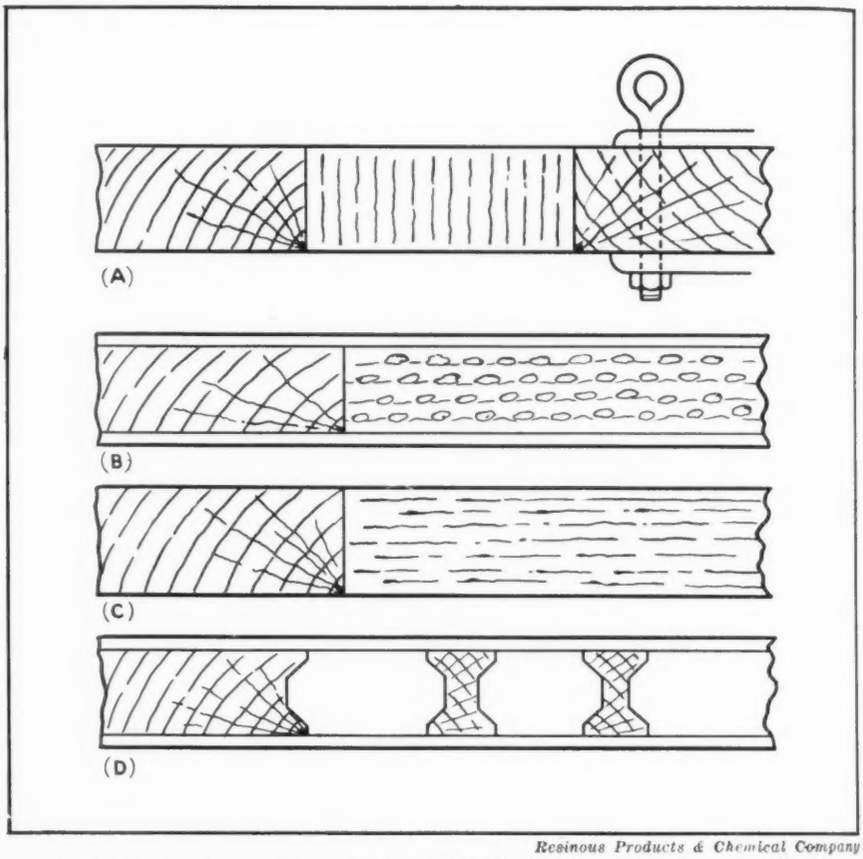
Physical Properties of Rubbers in Adhesives

Type of Rubber in Adhesive	Tensile Strength Before Aging	Tensile Strength After Aging	Viscosity Stability	Temperature Resistance	Application Characteristics	Tack Retention or Bonding Range	Solvent Resistance	Drying Time
Natural Rubber	Good	Good	Good	Fair	Good	Excellent	Poor	Depends on solvent and formulation
Reclaimed Rubber	Good	Good	Good	Fair	Good	Excellent	Poor	
GRS (Buna S)	Good	Good	Good	Good	Good	Fair	Poor	
GRI (Butyl)	Fair	Fair	Excellent	Poor	Excellent	Good	Poor	
Neoprene	Excellent	Excellent	Fair	Good	Fair	Good	Fair	
Buna N	Good	Excellent	Fair	Good	Fair	Fair	Good	
Thiokol	Poor	Poor	Excellent	Fair	Fair	Fair	Excellent	

F. J. Wehmer, Minnesota Mining & Manufacturing Company

Bakelite Corporation

"Compreg" propeller made of maple veneers saturated with phenolic resin. Properties include: 30,000 psi tensile, 40,000 psi flexural and 8,000 psi shear.



Resinous Products & Chemical Company

Sandwich constructions with metal faces, bonded with synthetic resin adhesives. (A) Aluminum face with end-grain balsa core; (B) Aluminum face, sponge core, with veneer interlayer; (C) Aluminum face with side-grain balsa core; (D) Aluminum face, hollow center with stiffener strips and veneer interlayer.

mand of the aircraft industry for a good metal-to-metal cement to be used in joining thin sheets of aluminum and stainless steel.

Chief use of the phenolic elastomers is for joining aluminum and stainless steel, but they can also be used with other metals and non-metals. However, the adhesive strength of the phenolic elastomers are unnecessarily high when used with comparatively weak material like wood. The high temperatures and pressures necessary for bonding operations with these glues could be injurious to some of the weaker materials. When bonding wood to metals, a two component method is used. A priming coat of metal-to-metal glue is applied to the metal and cured. A glue which is compatible with the primed metal and with wood is applied to both surfaces. They are then bonded together at relatively low temperatures.

Another metal-to-metal glue combines the rigidity of phenol formaldehyde with the thermoplastic properties of polyvinyl formal. This is supplied in two parts. A liquid phenol formaldehyde, which is used to coat the metal surfaces, and polyvinyl formal which is spread on the primer coating as a powder. The two metal surfaces are then joined with heat and pressure.

Phenolic elastomers are supplied in several forms: As a film with a liquid primer for metal surfaces, as a liquid, and as a two-component powder and liquid combination. All require high temperatures and pressures for proper bonding.

Applications

WOOD CONSTRUCTIONS AND ASSEMBLIES. These probably utilize a greater quantity of adhesives than any other material. The particular application for which the wood is selected should be the deciding factor in choosing the glue. For indoor applications, where moisture and temperature extremes are at a minimum, the manufacturer can take advantage of the savings offered by low and medium cost vegetable and animal glues. Where exposure to extremes of temperature, moisture and fungi is encountered, wood and plywood, demand the higher-priced thermosetting resin adhesives.

Some of the less moisture-resistant glues such as casein, sometimes perform better under extreme exposure conditions than laboratory experiments indicate. In actual practice, exposed joints are usually covered with a water-resistant paint or varnish, isolating the glue from deteriorating forces.

When the color of the wood is important, as in decorative applications, staining properties of the glue must be considered. Light colored urea glues should be chosen, because resorcinol and phenolic glues usually set in dark colors.

Shape, size and movability of the wooden assemblies should also be considered. Since thermosetting glues are supplied as either high, medium, or room temperature setting, limitations of available heating facilities become a factor in any choice made. For instance, complicated assemblies might be cured more conveniently at the as-

Resinous Products & Chemical Company

This rubber knife illustrates wood-to-metal gluing, replacing rivets. (A) Cast magnesium handle base with phenolic elastomer adhesive applied; (B) Wood strip coated with liquid adhesive; (C) Wood strip after powdered adhesive has been applied over liquid; (D) Assembled handle and blade before final finishing.

sembly point at room temperature, rather than in an oven, which would necessitate moving the assembly.

METAL-TO-METAL. Demands of the aircraft industry, where aluminum and stainless steel sheet are used in great quantity, have stimulated the recent development of metal-to-metal glues. The rigidity or high modulus of elasticity of the metal presents a problem. The usual thermosetting glues may hold at the temperature of application, but a change in temperature will set up strains caused by differences in thermal expansion coefficients, and break the bond. To solve this problem, the adhesive is modified, by lowering the modulus of elasticity until the adhesive film has sufficient flexibility to relieve the strains. The usual metal-to-metal adhesives are based on phenolics modified by one of the synthetic rubbers, or other resins.

Since metal-to-metal adhesives are used extensively in lap joints, instead of rivets or spot welds, consideration should be given to the optimum area of such laps. According to studies made at the Resinous Products and Chemical Company, any lap joint in shear tends to distort, combining a major factor of true shear along the joint, with a minor effect of true tension across the joint. The extent of distortion, or eccentricity is materially influenced by the thickness of the metal and the length of overlap.

WOOD-TO-METAL. Metal-to-metal adhesives have led to the development of wood-to-metal adhesives, and in turn, to a new class of structural materials having low density and high strength-weight ratios. Such "sandwich" or composite constructions have been responsible for improvements in aircraft, and in highway and railroad vehicles. Metal-clad plywood, made with phenolic adhesives modified with syn- is becoming increasingly used as an engineering material.

There are several procedures for metal-to-wood bonding:

1. Metal adhesives on one with wood adhesives on the other mating surface, single-stage process.
2. Adhesive-coated metal surfaces, two-stage process.
3. Film adhesive, interlaid in joint, especially for plywood.
4. Nonplywood applications, as solid wood to metal.

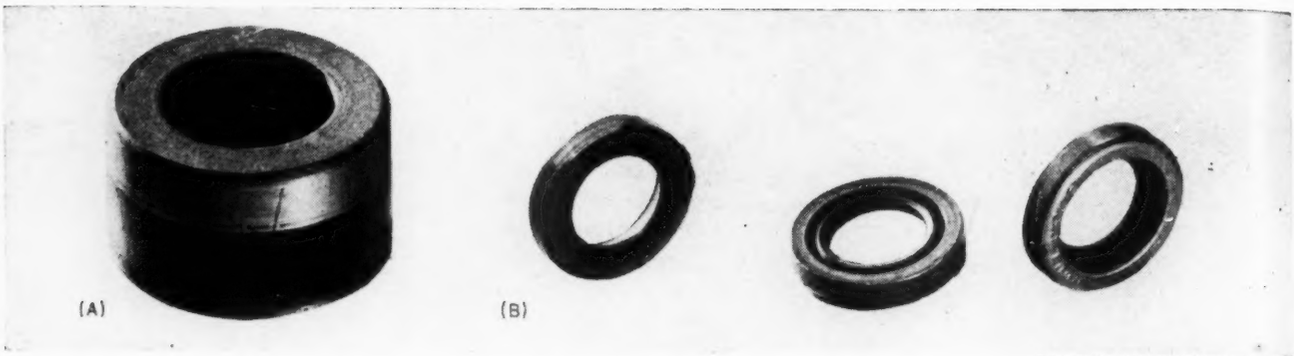
These are not alternate procedures, and the choice will depend on design, on construction of the product with equipment available, as well as on strength, durability, and cost limitations required for the product. Metal-clad plywood has many applications in fireproof constructions.

When thin metal sheets are cemented together, the joints usually have greater tensile strength than riveted joints but the resistance to peeling is low. One method of overcoming this difficulty is to rivet the ends of the glued strip.

GLASS. The largest application of adhesives for this material is in safety glass, in which a clear thermoplastic adhesive such as polyvinyl butyral supplements its clear rigidity to give

Bakelite Corporation

Phenolic cements, specially modified for high bonding strength and heat resistance, are used to bond lamp bulbs and radio tubes to metal and plastic bases.



Durez Plastics & Chemicals, Inc.

Phenolic cements are used in heavy-duty industrial parts. (A) Resilient coupling for a new oil burner "economy clutch" makes use of an adhesive blended from a phenolic resin and nitrile synthetic rubber, providing a high strength bond between the rubber and metal. (B) A cement composed of two phenolic resins in a suitable solvent bonds sulfurless rubber to a metal case in these oil seals.

Cycleweld Div., Chrysler Corporation

Bonding brake linings to shoes with phenolic elastomer cement makes riveting unnecessary and increases life of the lining. The assembly is placed within a metal band and a wedge is driven between the two brake shoes to obtain the pressure necessary for bonding. It is then put in an oven at the proper temperature, to form the completed assembly.

a durable, transparent product. The high modulus of elasticity and brittleness of glass exclude all thermosetting and high pressure adhesives. Since clearness is the principal glass property, light stable adhesives have been developed.

PLASTICS. Thermosetting plastics have a high modulus of elasticity, which puts them in a class with metals and glass. They require either thermoplastic cements or thermosetting cements which have been modified to give a low modulus of elasticity. If the thermosetting plastic contains a high enough percentage of a filler of low modulus of elasticity, there will be adhesion to the filler, and the properties of the thermosetting vehicle will not affect the bond.

Thermoplastic materials can be cemented to one another with the use of a solvent, as mentioned previously, or they can be heated sealed, by direct application of heat, or with high frequency current. With acrylic plastics, sufficient heat to cause fusion can be obtained by turning one piece against another at high speed. This is called "friction welding," and can be used to join thermoplastic rods to other materials.

When cementing a thermoplastic material to a metal or other dissimilar material, the quality of the bond is limited by the thermoplastic material. These "limitations" include relatively low softening temperatures and susceptibility to organic solvents. However, the same properties are advantages when thermoplastic materials are made into adhesives; the vinyl adhesives are especially versatile.

TEXTILES AND PAPER. In bonding textiles and paper, the fibers can be imbedded in any of the adhesives without causing strains. Because of the low strength of paper, the strength of the adhesive is secondary. Rather, the use of the finished textile or paper article is of primary importance. For waterproof, mildew-resistant paper packages, the heat-sealing polyvinyls are excellent, though high priced. For ordinary uses, the much lower priced starch and dextrin adhesives are equally suitable.

Recent Developments

A recent development in the adhesives field is the addition of cross-linking agents to vinyl resins, making them thermosetting. This thermosetting property together with the toughness of vinyl resin should give this adhesive extremely wide application.

Another recent development, is a specialty silicone adhesive which like all silicone products is noted for its heat resistance.

At present the cost of synthetic resins is comparatively high, but increased production and constantly improving production methods should reduce the cost of this important group of adhesives.

Modern adhesives cover a wide range of applications and leave little to be desired in strength and durability. Future advances can be expected in increasing ease of application.

TECHNICAL NEWS HIGHLIGHTS

New Instruments Aid Landing Field Safety

PROMISING TO INCREASE SAFETY of take-offs and landings at airports are two instruments developed recently at the National Bureau of Standards. One of these will have indirect value in landing field safety; since it is a test instrument. The other, while also used in testing, may have direct application.

Wind-Speed and Direction

Developed by S. H. J. Womack and F. Cordero of the Bureau of Standards, with the cooperation of the Navy Bureau of Aeronautics, a portable wind-speed and direction indicator of high sensitivity measures wind velocity by means of a propeller forced to head into the wind by a vane. Wind speed is registered on a magnetic tachometer coupled to the rotating propeller shaft, while wind direction is at the same time indicated on a circular scale by a pointer connected to the shaft of the vane.

Accurate measurement of low wind velocities is necessary in take-off tests of aircraft, since design specifications call for certain standards of performance at zero wind velocity. In practice, a wind speed of zero is seldom experienced. Hence, the usual procedure is to record wind velocity at the time of the test and correct the test results to zero wind speed.

Until this wind-speed and direction indicator was developed, the measurement of low wind velocities at landing fields was hampered by the lack of a compact, portable, easily-assembled wind-velocity gage of adequate sensitivity. Most of the devices available for measurement of wind speed were not well suited to use in take-off tests. Either their range was not sufficiently low, or they required heavy, elaborate equipment such as an amplifier or other electronic apparatus, batteries, or a power line out to the landing strip. Usually a second instrument was necessary to indicate wind direction.

The new portable assembly is light and self-contained, requiring no power, either electrical or mechanical, except that taken from the wind for turning the vane and rotating the propeller. It records both direction and speed of the wind and is easily adjusted for different ranges of wind speed. It is automatically temperature-compensated, and can be used outdoors in all weather.

The instrument consists of four principal parts: An anemometer (or wind-speed meter), a wind-direction indicator, a tripod support, and a leveling device. The anemometer is rigidly attached to the direction indicator, and the two are mounted so that they rotate together on a vertical shaft supported by a tripod.

A small wooden propeller coupled directly to a magnetic tachometer constitutes the velocity indicator. The tachometer is a "magnetic-drag" instrument, in which the rotation of a small magnet within a conducting cup sets up eddy currents in the walls of the cup. The resulting torque upon the cup, caused by interaction of the induced currents and the field of the magnet, acts against a hairspring to move the pointers on the dial.

Wind-tunnel performance tests with the new instrument have been satisfactory. When the air speed is increased

Landing Aids Experiment Station

Heavy fog is cleared by high pressure burners from the runway at the Landing Aids Experiment Station, on which a plane is landing. Transmissometers developed at the Bureau of Standards are being used in study of fog dispersal methods.

slowly from zero, the vane, if initially displaced as little as five degrees from the equilibrium position, lines up with the wind direction before the propeller starts turning, and does not oscillate abnormally at air speeds up to the full range of indication.

Transmissometer

The second of these airport safety aids is an electronic instrument developed at the Bureau of Standards for measuring atmospheric visibility. The new device, called a transmissometer, was designed in the Bureau's airport lighting laboratory to reduce the human factor in visual estimates of distance, particularly in foggy weather. The transmissometer indicates visual ranges and is adaptable for another important phase of aviation, the control of high-intensity airport approach lights, as well as control of fog dispersal equipment.

Visibility of objects or lights depends on the transmission of light by the atmosphere. A correlation exists between the transmissometer readings and the maximum distance at which markers or lights can be seen by a trained observer. If the atmosphere is uniform, this distance can be determined directly from the readings, giving a more complete indication of visibility than general terms such as foggy, hazy, and clear which have been frequently used in describing atmospheric conditions.

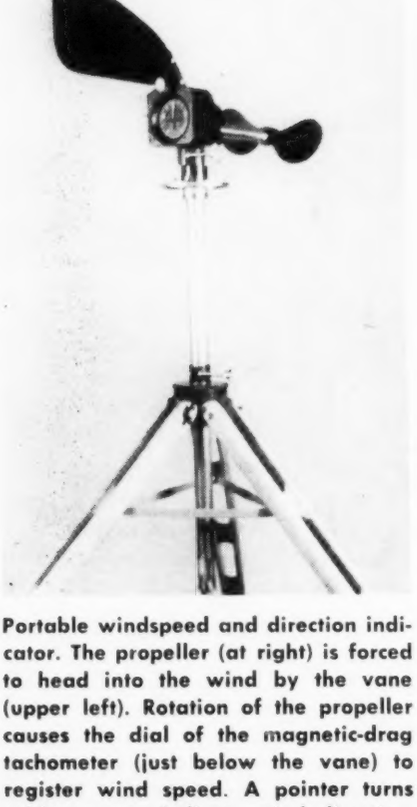
The transmissometer consists of a light transmitter, a phototube receiver, an amplifier, and an indicator. The distance between the transmitter and receiver depends on the particular application; in tests, distances up to 4000 feet have been used successfully. The amount of light reaching the receiver from the transmitter is determined by the fog density or other atmospheric conditions in a direct line between the two pieces of equipment. The light falling on the receiver actuates an electronic circuit whose output is an electric current which varies directly as the amount of light received.

The receiver consists of a lens, a diaphragm, a photo-pulse unit and an amplifier. Light from the transmitter, focused by the lens on a "pinhole" in the diaphragm, falls on the phototube receiver and generates pulses whose frequency is directly proportional to the intensity of light incident on the phototube. These pulses are amplified and transmittted to the indicator.

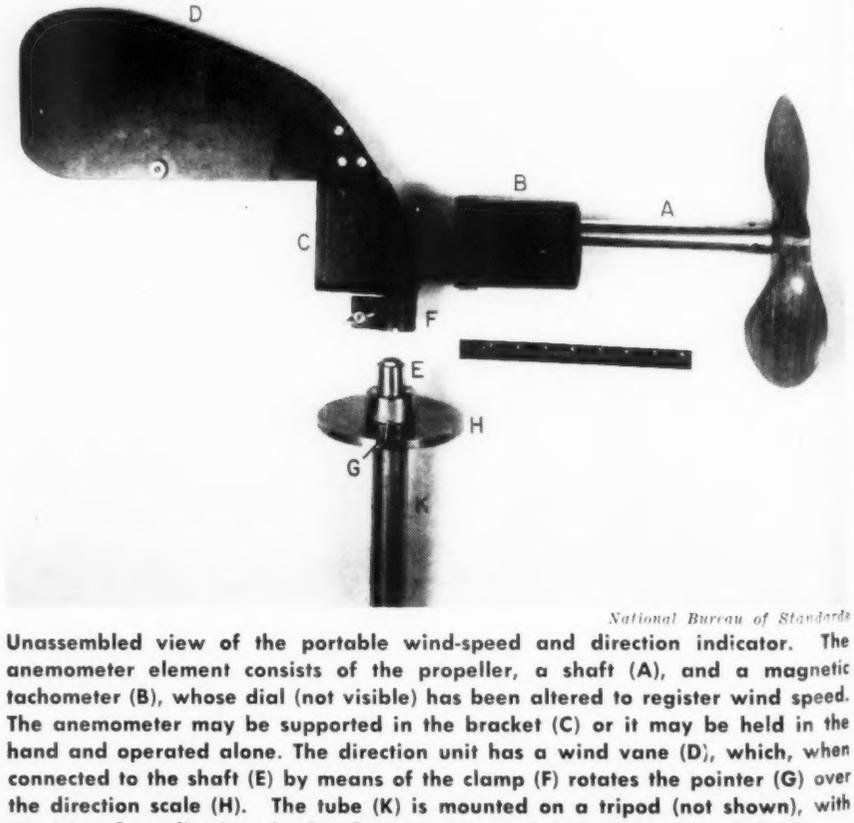
The indicator consists of a two-stage amplifier, a frequency-measuring unit and a calibrator that provides a calibration frequency of 60 pulses per second. The indicator unit, which gives both a dial reading and a revolving drum record, can be placed as much as ten miles from the receiver. This allows installation of the indicator in the control tower and the use of more than one transmissometer to cover various parts of the airport with all indications centrally observed.

A special use of the instrument was indicated during tests at the Joint Landing Aids Experiment Station, Arcata, California, when it was found that the transmissometer began to give evidence of the approach of fog as much as six hours before any trace could be seen by the human eye. Similarly, it frequently gives indications of the lifting of fog long before changes can be seen.

At the present, the principal applications of the transmissometer to aviation are: (1) As a control for high intensity light and fog dispersing equipment; (2) to supplement the periodic visual observations by a continuous record of atmospheric conditions; (3) to replace visual observations where trained observers or satisfactory marks, especially lights, are not available; (4) to provide a more accurate indication of visual ranges over a restricted area remote from the observer, particularly in an approach zone; (5) to record the variations and rate of change of conditions of visual range; and (6) to provide more accu-

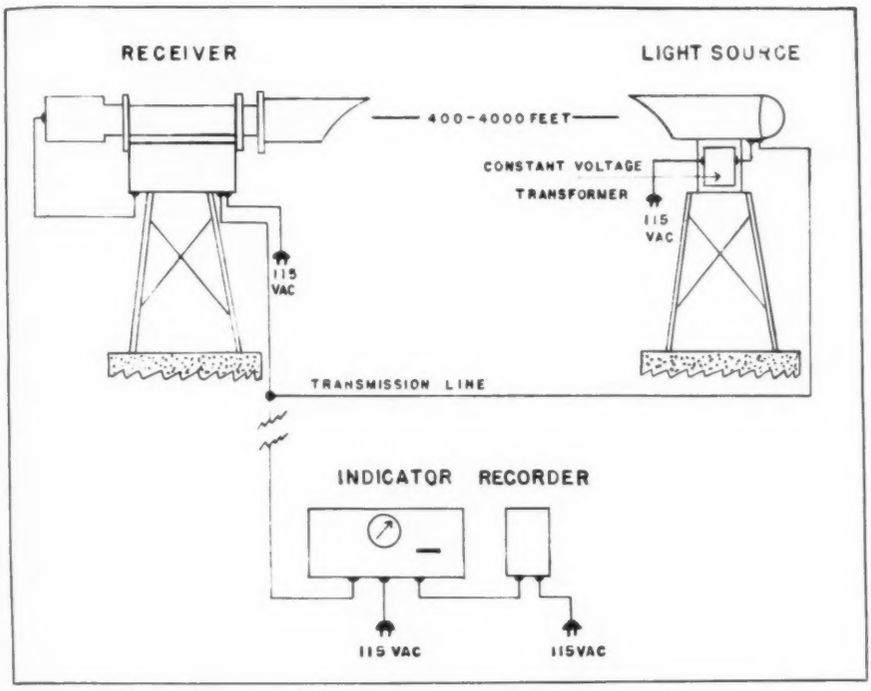


Portable windspeed and direction indicator. The propeller (at right) is forced to head into the wind by the vane (upper left). Rotation of the propeller causes the dial of the magnetic-drag tachometer (just below the vane) to register wind speed. A pointer turns with vane to indicate wind direction.



National Bureau of Standards

Unassembled view of the portable wind-speed and direction indicator. The anemometer element consists of the propeller, a shaft (A), and a magnetic tachometer (B), whose dial (not visible) has been altered to register wind speed. The anemometer may be supported in the bracket (C) or it may be held in the hand and operated alone. The direction unit has a wind vane (D), which, when connected to the shaft (E) by means of the clamp (F) rotates the pointer (G) over the direction scale (H). The tube (K) is mounted on a tripod (not shown), with provision for adjusting the height from 5½ to 7 feet above the ground.



Arrangement of components of the transmissometer. The distance between the light source and receiver is dependent upon the particular application. The indicator and recorder are placed at any convenient location within 10 miles of the light source, a powerful 350,000-candlepower sealed reflector, and receiver.

rate indications of the visual ranges when visibility becomes poor.

In controlling high-intensity airport approach lighting and fog dispersal equipment, a knowledge of the fog density in the region of the lights is required. In general, the determination of fog density from visual range observations when the visual range is less than one-fourth mile is unsatisfactory because of the lack of a sufficient number of suitable marks and because of the large changes in fog density corresponding to relatively small changes in visual range. On the economic side, because of the enormous cost involved in using high-intensity lights and fog dispersal equipment, the transmissometer offers an accurate method for determining the optimum wattage and fuel.

Industrial Groups Invited To Evaluate German Documents

AN INVITATION TO TECHNICAL SOCIETIES, trade associations and other private industry groups to cooperate with the Office of Technical Services, Department of Commerce, in evaluating an estimated 500,000 technical documents revealing the details of Germany's wartime industrial technology, has been issued by John C. Green, OTS director.

The documents, all on microfilm reels and in German, have been collected over the past two years by American technical investigators in Germany under OTS sponsorship. The material was selected from the files of major German industrial plants, research laboratories, universities, and government offices because of its potential value to American industry. Included are 5,000,000 pages of technical data reproduced on 5,000 mircofilm reels.

As rapidly as the microfilm reels are received, OTS catalogues them and publishes the titles in its weekly "Bibliography of Scientific and Industrial Reports," available from the Superintendent of Documents for $10 a year. "Publication of these abstracts, however, is not enough to bring the documents to the attention of American businessmen," Mr. Green said. "If American firms are to make full use of this technical data, the documents must first be studied, evaluated and in many cases, translated by technical experts. They must then be made readily accessible to all business firms. Very few firms have technical experts who can make use of the documents in their present form."

OTS plans to compile and publish a compendium of German wartime technology based on these documents. The material in the compendium will be divided into appropriate sections—automotives, pharmaceuticals, utilities, diesel engines, machinery, and the like—each outlining German developments in a special field. Each section will refer to the microfilm reels containing the detailed information. With this reference work at hand, any firm can quickly locate the German documents pertinent to its operations.

Mr. Green explained that OTS can do no more than coordinate the work involved in completing the compendium. However, if private industry, particularly trade associations and technical societies, will cooperate by furnishing the technical personnel to study and evaluate the documents, the job can be done. According to Mr. Green, experts who volunteer their services to the compendium project will benefit by being the first to scrutinize the original German material. They will also be free to publish articles based on the documents in technical journals under their own names, providing that the same articles are also made available for publication in the compendium.

Any trade association, technical society, firm, or individual interested in assisting in the compendium project can write to John C. Green, Director, Office of Technical Services, Washington 25, D. C., for further details. The letter should state the volunteer's field of interest and summarize his technical background for the work.

Largest Multi-Jet Bomber Uses Six Aircraft Gas Turbines

LARGEST MULTI-JET BOMBER of conventional design ever built, the Glenn L. Martin XB-48, powered with six General Electric aircraft gas turbines, has been announced by the Air Force. The Martin Company required only 14 months from the hangar for ground testing. This was a full year ahead of the normal development time of a new military airplane.

The new airplane, which has three jet engines housed in each wing, is a long-range high-speed bomber and incorporates several startling innovations, the AAF announcement said. Due to the thin wings required for its exceptionally high-speeds, the XB-48 is pioneering a new "bicycle type" landing gear especially designed for airplanes flying at speeds approaching the transsonic range.

The powerful XB-48 has a wing span of 108 ft, 4 in. length of 85 ft, 9 in. and height of 27 ft, 6 inches. The wings are of a special design developed by Martin engineers.

As the wings are thinner than in an airplane built for slower speeds, there

is not sufficient space to house the large main wheels required for safe landings and take-offs. In the XB-48, the two main wheels are placed bicycle style in the center of the ship and retract upward into the fuselage. A smaller wheel is located near each wing tip to give stability during taxi operation. These retract into shallow wells in the wings.

In constructing this all-jet airplane, Martin utilized data which has been obtained by experimenting for some time with jet engines and the construction of two experimental patrol planes combining reciprocating engines and jets. One is the XP4M-1, which uses two General Electric 1-40 gas turbines and two Pratt and Whitney reciprocating engines. Both of these aircraft are now in test stage.

The new Martin XB-48, which weighs 58,500 pounds, is the latest of a number of types of all-jet aircraft built by various manufacturers for the AAF and the Navy. They include the XB-46, built by Consolidated Vultee, and the XB-45 North American bomber, both powered with four of General Electric's TG-180, and designed for speeds in the trans-sonic range.

German Rubber and Plastics Developments Evaluated

MANY OF GERMANY'S wartime developments in synthetic rubber and plastics are evaluated in two reports by the Office of Technical Services, Department of Commerce.

The newer German synthetic rubber processes developed toward the end of the war were mainly laboratory developments. Buna S3, the best type of synthetic rubber produced in bulk, was considered capable of further improvement. The advantage of these long chain products, without much side-branching, comes from their superior elasticity and elongation. The abrasion resistance of acid buna would be of value in the tread of a natural rubber tire casing.

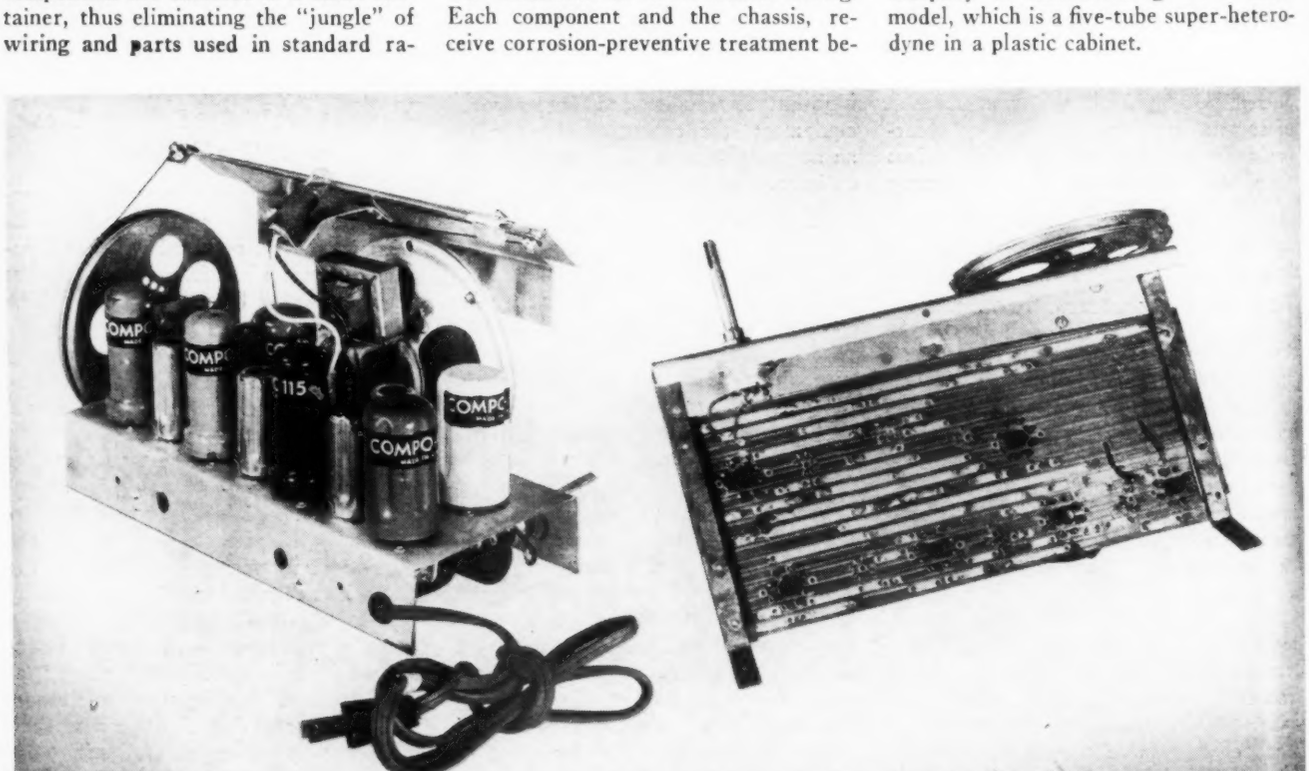
In the bonding of buna to metals, the "Desmodurs" are said to be satisfactory with magnesium alloys and that the only metal treatment necessary is sandblasting followed by a gasoline wash.

Orders for the reports: PB-49192 and PB-49986, should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C.

New Radio Built of Basic Subassemblies

A NEW TYPE OF RADIO RECEIVER that combines all of the many small intricate parts into six subassemblies or "components", has been developed by the Cosmo Electronics Corporation, New York, N. Y. In the new receiver, called the "Cosmo Compo", the basic electronic components are enclosed in a small container, thus eliminating the "jungle" of wiring and parts used in standard radios. When anything goes wrong with the set, the user can replace whatever circuit is faulty by plugging in a new circuit in the same manner as a radio tube. There are no soldered wire connections between them and the tube sockets. Shortly, the new metal chassis will eliminate all conventional wiring. Each component and the chassis, receive corrosion-preventive treatment before assembly.

It is claimed that the new set can be repaired by the owner without any knowledge of electronics. The radio user is safeguarded against "unscrpulous repairmen who play on the ignorance of a user." At the moment the company is concentrating on a table model, which is a five-tube super-heterodyne in a plastic cabinet.



Numerous elements of conventional radio set are replaced by basic subassemblies, which can be plugged in like ordinary vacuum tubes. Expected to be put into production is "stamped wiring", at right, which will further simplify the set.

WASHINGTON NOTES

Military Stockpiling Hampered By Congress

The Army Navy Munitions Board, the top government agency charged with industrial mobilization plans in the event of a future war, has been hampered by Congressional action.

On the Board's most urgent programs has been the procurement of strategic and critical materials. Even though it has deferred procurement of some sixty commodities until industrial needs have been met, the Board for the past three years has been unable to obtain minimum requirements of many materials. In addition, stockpiling has been held up by high prices.

At the present time, however, the situation seems exceptionally urgent, and it is the opinion of our military leaders that positive steps must be taken to bring the stockpiles into some semblance of order and completeness. Although it is distasteful to them, the needs of national defense require that the Board go into competition with private industry to obtain at least a minimum inventory.

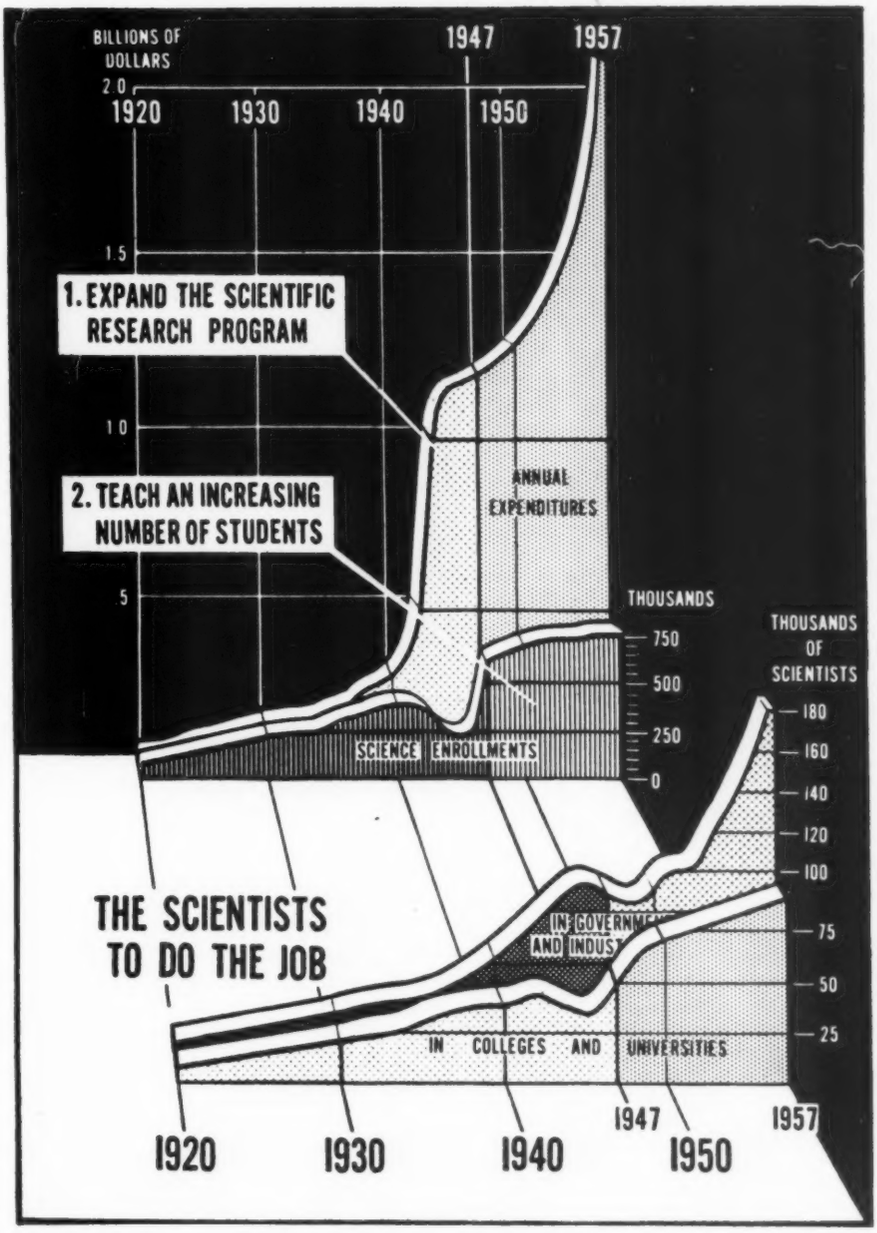
Congressional "suggestions", which had previously been followed, now must be abandoned. In addition, the high price situation must also be overlooked. The monetary goal for an adequate stockpile, formerly considered to be about 1.8 billion dollars, was revised upward last spring to 2.2 billion dollars, and more recently to 2.5 billion dollars.

The Marshall plan, calling for a 20 billion-dollar drain on American production and resources during the next four years, was one of the most motivating forces behind the Board's change of plans. Faced with the alternative of marking time for at least another four years, during which time very little stockpiling could be done, the Board decided to fight for a stockpile at once.

The international situation has also had an energizing effect on the stockpilers. Reports on Russia's industrial mobilization program are constantly filtering through the "Iron Curtain." These tell of industrial empires under construction in Siberia, beyond the Urals, in the Ukraine and around Moscow.

The one promising note in this situation is the fact that the Munitions Board has nearly completed its initial draft of the M-Day program. The plan, an extremely lengthy one, will shortely be transmitted to the military establishments, the Congressional Armed Services Committees, various government agencies and industrial advisory boards. After initial comments have been received from these sources, the document will be handed to a selected group of large industrial firms. Following this, the amended plan will be made public.

Another activity of the Board, to be announced shortly will be the production of a "textbook" on the operation of a future war production board, which will include a critical discussion of the last one. Following that the Board will issue a study of manpower, and finally, one on plant dispersal.



THE JOB TO BE DONE in the nation's research establishments is graphically illustrated in this chart prepared by the President's Scientific Research Board. It appears in volume I of "Science and Public Policy," a series of reports prepared by the Board, under the direction of John R. Steelman, Assistant to the President.

Navy Fire Prevention System Utilizes Exhaust Gases

A new system for reducing aircraft fire hazards by blanketing vacant spaces, inside and around the fuel tanks with low oxygen-content gases from the engine's exhaust has been successfully installed in two Navy planes.

The system, which involves the cooling of inactive exhaust gases by a heat exchange before they are led through a small "bleed" line into the gasoline tank, was developed for the Bureau of Aeronautics by the Curtiss-Wright Corpora-

tion research department and Cornell Laboratories, Cornell University.

Although atmosphere normally contains 19 percent oxygen, a reduction of only five percent in oxygen is usually sufficient to suppress combustion. The new exhaust gas system maintains the oxygen level in air immediately adjoining an aircraft's fuel supply at approximately 10 percent, or well below the safety limit.

The system eliminates extra weight in the form of carbon dioxide bottles or inactive gas generators usually used to "purge" partially filled gasoline tanks. It can be used in both combat and non-combatant aircraft. Simplicity and efficiency of operation are features of the new system. When gasoline is used from the plane's tank, the exhaust gases enter and the remaining fuel is blanketed with low oxygen content vapor, incapable of supporting combustion. Other lines maintain a constant flow of vapor into the wing sections surrounding the fuel cells, lessening the fire hazard from possible leakage.

Before exhaust gases enter the fuel tanks, they are cooled from 900-1200 F to approximately 70 F by a heat exchange. From the heat exchange they go to a pressure relief valve which vents the system when critical internal pressures are built up, such as in a long climb. Farther on, a check valve prevents back-flow of gases, and a vacuum breaker near the tank allows outside air to enter the system in case of failure.

Original research on this new fire prevention system began in 1943 when the Curtiss-Wright research department was invited by the Navy to study the problem, along with the National Defense Research Council and the British Government. Several methods were evaluated, but the use of engine exhaust gases was the most efficient.

At present, the new unit has been tested only on aircraft without turbo superchargers. With a turbo supercharger the unit could be installed between the engine and the turbine, as an auxiliary fuel pressurization system.

Cornell Laboratories, successors to the Curtiss-Wright research department, now is engaged in testing further the system in various installations. At present, the fire prevention system has been successfully installed in an R5C Commando and a PB4Y Privateer. The Privateer was recently demonstrated to Bureau of Aeronautics personnel at the National Airport, Washington, D C.

Continuous Casting of Alloys Made Possible by New Process

AN IMPORTANT METALLURGICAL DEVELOPMENT is claimed to mark a basic advance in the manufacture of specialized alloy steels, according to an announcement by The M. W. Kellogg Company. The metallurgical process is an electric ingot method for continuous metal casting. Alloying elements are continuously fed at a controlled rate into an electrical apparatus from which air is excluded, and in which an ingot of any desired analysis is produced by progressive solidication, a method long recognized as fundamentally sound but never before attained commercially.

The accuracy with which the alloying elements are metered, combined with the fact that the ingot is progressively solidified in the same container in which the raw materials are melted, provides uniformity of chemical analysis and of physical properties. The usual transfer of hot metal from ladle to mold which might give rise to non-uniformity of product is eliminated. The uniformity is obtained not only within an individual ingot but also is carried over from ingot to ingot.

A small shipment of billets made by the Kellogg Company's continuous casting or "electric ingot" process. The billets are each 9 in. in diameter and 21 in. long, of special high temperature alloy for the production of gas turbine rotors.

As a result of this uniformity and the way in which the ingot is formed, the alloy is substantially free of the defects observed in ingots produced by usual methods of alloy manufacture. Highly segregated areas in the centre of ingots, internal bursts, segregated carbides and central cavities in the ingot are defects which are prevented from occurring by the new process.

High-speed, high-temperature, turbine wheels, when fabricated of a ductile alloy, have "toughness", the ability to equalize stresses and so to adjust to the abnormal conditions without failing. Standard test bars taken from the center of a turbine wheel fabricated of a high temperature alloy made by the Kellogg method exhibited an elongation of more than 20 percent, whereas turbine wheels fabricated of an alloy of the same chemical analysis but made by other commercial methods exhibited an elongation in the order of 2 percent. Generally, in such products, ductility is 5 to 10 times greater in Kellogg alloys.

Small research heats of 25 to 50 lb. are produced quickly and without any special conditions in the same equipment used for volume commercial production. This permits quick delivery of small orders and enables translating experimental data to full-scale operations.

Applications of the process include turbine wheels for turbo-jet aircraft engines and many other high temperature applications; high speed tool steels; and stainless steel alloys of all types, especially where free machining is a desired quality.

MEETINGS

December 1–5
American Society of Mechanical Engineers—Annual meeting, Atlantic City, N. J. Headquarters hotel: Chalfonte-Haddon Hall.

December 3–5
National Association of Manufacturers — Annual Congress, Waldorf-Astoria, New York.

December 4–6
Society for Experimental Stress Analysis—Annual Meeting, Hotel Pennsylvania, New York, New York.

December 26–31
American Association for Advancement of Science—National Meeting, Chicago, Ill.

December 29–30
American Chemical Society — Fourteenth Annual Symposium, Chicago, Illinois.

January 12–16
Society of Automotive Engineers—Annual Meeting, Hotel Book Cadillac, Detroit, Mich.

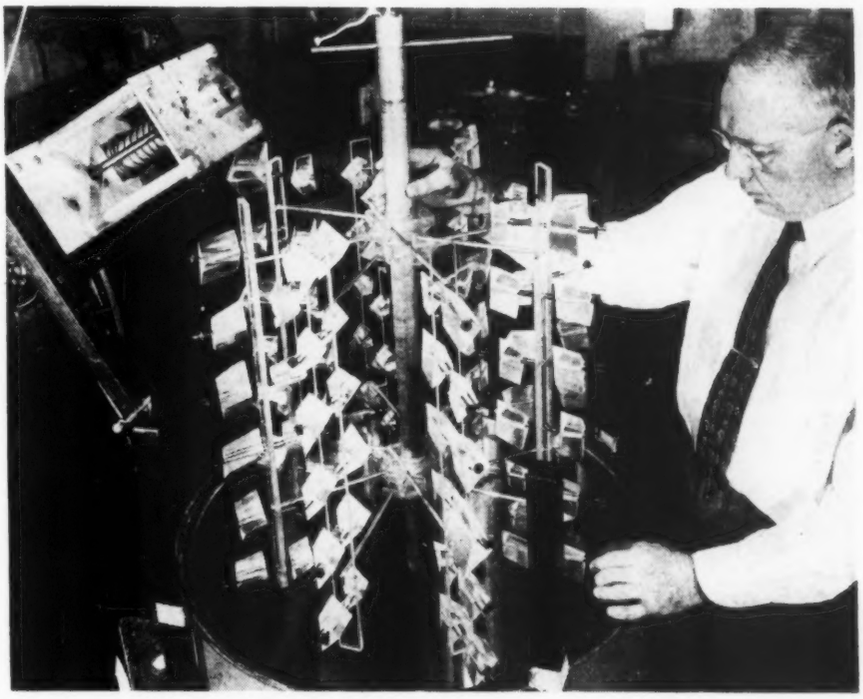
January 12–16
National Materials Handling Exposition — Public Auditorium, Cleveland, Ohio.

January 26–29
Refrigeration Equipment Manufacturers Association—Refrigeration and Air Conditioning Exposition, Cleveland, Ohio.

February 2–6
American Society of Heating and Ventilating Engineers — 8th International Heating and Ventilation Exposition, Grand Central Palace, New York, New York.

March 1–6
American Society of Mechanical Engineers—Spring Meeting, New Orleans, La.

March 22–24
Chicago Technical Societies Council—Chicago Production Show, Hotel Stevens, Chicago, Ill.



SEEDS OF SYNTHETIC CRYSTALS are about to be lowered into a growing tank at Bell Telephone Laboratories, where engineers have developed a method of culturing them as a substitute for scarce but heretofore indispensable quartz. In a few years such artificial crystals are expected to replace as much as 90 percent of the natural quartz used in long-distance telephone systems. Some circuits are already operating with the new synthetics.

The new crystals, ethylene diamine tartrate, are known as EDT. Although these crystals differ markedly from quartz in chemical composition, both are piezoelectric in character; that is, they can convert mechanical energy to electrical energy or they can reverse the process.

A small slice, or plate, of such a crystal will vibrate with unvarying frequency when electric current is applied to it. Telephone engineers employ this characteristic of quartz—and now of EDT—in sending many telephone conversations over the same wires at the same time but at different frequencies, using crystal filters to guide each conversation into its proper channel.

Protective Coating of Metals Covered in OTS Reports

THE OFFICE OF TECHNICAL SERVICES has announced publication of a special bibliography containing a complete list of OTS technical reports and documents on protective coatings for metals. The bibliography cites author, title, price, reference number and gives a brief abstract of each of the 230 reports listed.

Included are research reports and patent applications from I. G. Farbenindustrie in Germany as well as various specifications of the U. S. Bureau of Ordnance and reports on Quartermaster Corps investigations. The reports present technical information on a large number of metal protective coatings, such as: Synthetic coatings for steel, wax coatings for electrical components, phosphate coatings, coating agents for magnesium and magnesium-aluminum alloys, protective coatings for ships bottoms, organic coatings, vitreous enamel coatings on aluminum, and German plastics coatings.

The bibliography lists all of the protective metal coating material received by OTS through October 1, 1946. Later reports will be listed in OTS' weekly Bibliography of Scientific and Industrial Reports. Free copies of the Bibliography of Reports on Protective Coatings for Metals can be obtained by addressing the Reference Service, Office of Technical Services, Department of Commerce, Washington 25, D. C.

German Zinc Industry Report Published

A STUDY of the German zinc industry is presented in a British technical report on the uses of zinc in Germany by the Office of Technical Services, Department of Commerce. The report gives information on equipment and methods used in rolling, extruding, alloying, die casting and drawing of zinc. One chapter of the report covers the use of zinc as a coating and describes hot

dip, electro-galvanizing and spraying methods.

The chapter on the zinc alloy die casting industry, based on a survey of approximately 40 plants, includes a description of a novel vertical casting machine in which molten metal was injected by air pressure from a cast iron bottle. The machine had a 17½ lb casting capacity with a 24-in. square die platen and occupied an 8 foot by 6 foot area. It was said that the closing pressure was as low as 40 tons.

Zinc alloy wire was used in Germany to a large extent as a substitute for copper or aluminum wire, the report states. The wire was produced almost entirely by rolling down cast bars to rod form and then by drawing. This process was stated to be cheaper than first extruding and then drawing. A method in use at 0.8 one plant consisted of first casting circular discs which were rolled in about cm thickness and one meter diameter. The rolled disks were then cut up spirally into rough 0.8 cm square rod which was later drawn down to wire.

Orders for the report, PB-75873, "The Uses of Zinc in Germany" (microfilm, $6; photostat, $17) should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C., and should be accompanied by check or money order, payable to the Treasurer of the U. S.

Bearing Applications Discussed At ASTE Convention

AT THE SEMI-ANNUAL MEETING of the American Society of Tool Engineers, held in Boston, October 30 through November 1, many papers of interest to design engineers were discussed. A special session on bearing applications was held on Friday evening, October 31. Among the speakers were E. W. Miller, Vice President of the Fellows Gear Shaper Co.; F. E. Ericson, Executive Vice President, Barden Corp., who spoke on "Bearing Selection"; and Lewis Sandler, Executive Vice President, Johnson Bronze Co., who spoke on "Plain Bearings".

Foreign Reports

. . . . . from McGraw-Hill World News

French Modernize Equipment For Automobile Production

France's nationalized Renault automobile company has installed modern equipment for its new 19hp. rear-engine light car. Much of the new standard equipment comes from the United States.

Specialized machines, however, are being made largely by Renault or other French firms. These include a "transfer" machine, electronically controlled, which takes a rough casting and passes it automatically along a work table where eight different tools, in series of two, finish it completely. One worker feeds in the castings and a second one dismounts it at the end. Electronic control boxes are in the background.

A French-made multiple spot weld machine has also been installed for welding of panels around the window openings. This machine welds two inside panels with 40 spots and two outside panels with the same number of spots, all at the same time.

Renault officials hope, with this and similar equipment, to have the most modern assembly line in Europe for their new car. Volume production will soon be reached, and it is hoped eventually to push output of this new model to 300 daily.

Program Developed for World Engineering Conference

Plans for the further development of an international program of the World Engineering Conference, Conference Technique Mondiale, were recently discussed by the executive committee and general assembly of the Conference, meeting in Zurich, Switzerland. The Conference, founded in Paris in September 1946, strives to coordinate and represent all the engineering and technical associations of the world through its international organization. Thirty countries are now members of the conference and are represented by national committees selected by the associations of engineers and technicians in each country.

Each national committee sends three delegates to the General Assembly, which is the governing body of the conference, directing the general line of business and approving and controlling the execution of the program prepared by the Executive Committee.

The program for 1948, as approved by delegates from 25 countries at the Zurich meeting, will include the exchange of engineers and technicians among countries of the world, coordination of documents published along scientific lines, preparation of an international yearbook of engineering associations through aid from UNESCO, publication of a general bulletin over the activities of the Conference, and the creation of a special committee to study social problems of the world as related to technical developments.

Another point in the 1948 program will be the continuance of aid in the rebuilding of the Polytechnical School of Warsaw, Poland. As a contribution toward peace and international cooperation, scientific books and periodicals as well as laboratory equipment have been sent to the school by Conference member nations.

Under the auspices of the World Engineering Conference, an international Technical Congress will be held in March 1949, in Cairo, Egypt. The Congress themes will be: (1) Matters of a general technical nature; (2) social and professional problems of the engineer, and (3) technical progress in Egypt and the Middle East. Plans for this Congress, to which all engineering and technical men of the world will be invited, will be developed when the executive committee of the World Engineering Conference meets in Paris in January.

French Aluminum Refrigerator

An aluminum refrigerator is slated to get into production soon in France. With polished white enamel surface, the 6 cu. ft. box stands, 4.7 ft high. Weight is only 215 lb.

The maker will be one of the French nationalized aircraft companies, Societe Nationale de Constructions Aeronautiques de Sud-Ouest. This firm, in common with most in the French aircraft industry, was hard hit by cancellation of war orders for planes. For the past year they have been casting around for some other product to occupy a portion of their machines and men, preferably using relatively-plentiful aluminum as a material. One result is the new refrigerator.

Among the different aircraft firms, production has begun of tractors, and aluminum buses, furniture and suitcases. Volume output of these items as well as of the refrigerator is expected in the next six months.

Toughness of Welded Joints Tested by Load-Carrying

DETERMINING THE TOUGHNESS of welded joints in steel structures by measuring the load-carrying ability of specimen welds is proposed in a research report by the Office of Technical Services, Department of Commerce. The report was prepared for the Watertown Arsenal Laboratory, Watertown, Mass., by Capt. S. A. Herres, now with Battelle Memorial Institute, Columbus, Ohio.

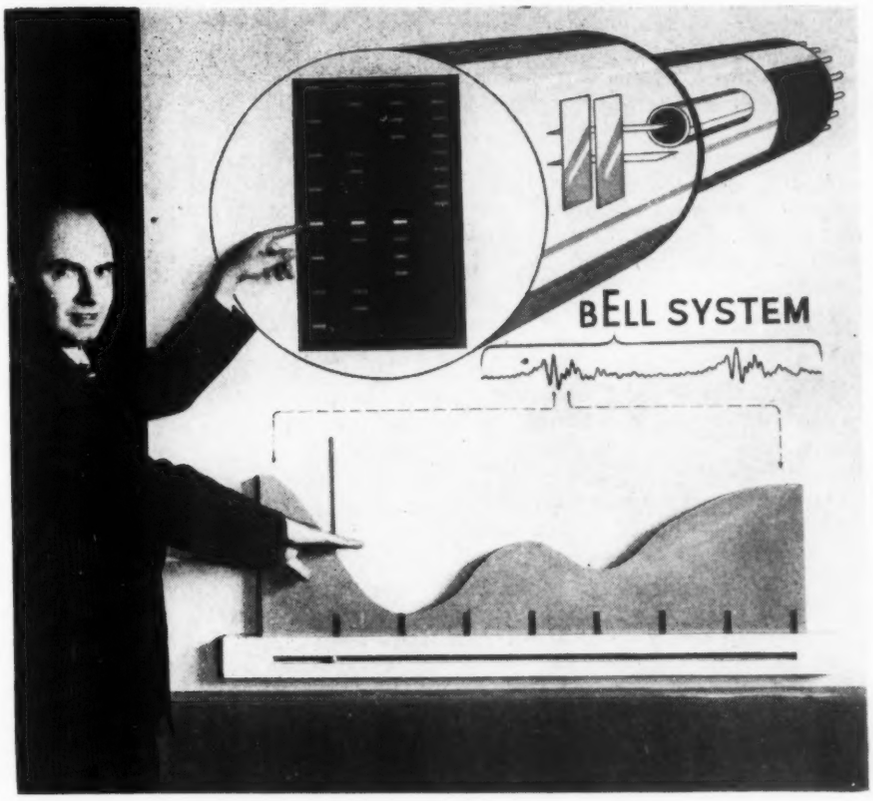
The proposal, is that tests of specimens including welded joints should be compared with test results on similar specimens of unwelded metal. The tension side of the welded specimen should represent the irregular surface of the weld. In this way, the toughness or ability of the welded member to adjust its shape to withstand the load can be evaluated, just as the toughness of unwelded steel is measured by applying a load on a bar that contains a small notch.

A manifestation of toughness which is very important in many applications, is the property of plastic flow. Instead of cracking at the notch or rough place, a piece of tough steel flows enough to adjust its section not only to reduce the stress concentration but also to line up any weak places in the direction of the force.

Toughness of bars of unwelded metal is determined by standard tests that depend upon the effect of notching as compared with similar loading on unnotched specimens. Toughness is manifest by flow that smoothes out the effect of the notch. The notched-bar tests are not suitable for welds, however, for two reasons: The material generally varies so much that it is impossible to get representative values, and the irregular surface of the weld gives the effect of additional notching. For these reasons, comparison of welded and unwelded specimens is urged as a better criterion of toughness.

The report gives the results of a series of bend tests on steel heat-treated to approximately equal strength but to different levels of toughness and with various kinds of notching. Tests were made at plus 70 and minus 40 F. The results show that deep notching and low testing temperature greatly decreased the load-carrying ability of the more brittle specimens.

Orders for the report, PB-49082 (photostat, $1; microfilm, $1) should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D.C. with a check or money order, payable to the Treasurer of the United States.



Coding Tube Allows Multiple Transmission

CODING TUBE, developed by engineers of Bell Telephone Laboratories, was revealed in connection with the first demonstration of a new communications technique for long-distance telephone transmission which has been developed by the Laboratories. Known as PCM, for pulse code modulation, the new technique is entirely different from earlier forms of pulse modulation, and promises marked freedom from noise and interference.

Basically it is a method of transmitting the human voice by various patterns or codes. In a 96-channel laboratory model now under development, such tubes will handle code signals at the speed of 5,376,000 pulses per second.

Although the new system is expected to be used primarily as an adjunct to the telephone network, it can also be used to transmit radio programs, pictures, and teletypewriter signals. Pulse modulation, or "sampling," transmission in general is expected to be used on broadband communications systems on which many conversations can be carried simultaneously. Such transmission is so named because the continuous speech wave is sampled very briefly and rapidly and only information regarding these samples is transmitted. For a standard telephone circuit 3000 to 4000 cycles in width, samples taken at the rate of 8000 per second are adequate. Just these brief samples are sufficient to reconstruct the original wave with high fidelity.

Since information regarding the sample can be sent very quickly—in roughly a millionth of a second—the system can carry not just one but many different telephone conversations, each of which is "sampled" in turn and then reassembled at the receiving end. Thus, a transmission system of this type carries a sample from one conversation, then from another and so forth, repeating the sampled cycle through as many conversations as are being transmitted.

Deterioration Preventives Described in Report

AMERICAN WARTIME RESEARCH for the prevention of deterioration of optical instruments, textiles, synthetic resins, plastics, photographic equipment and other material in tropical climates is summarized in a report by the Office of Technical Services, Department of Commerce. The research was carried out by the tropical deterioration administrative committee of the Office of Scientific Research and Development.

The report explains that in tropical climates equipment and supplies are exposed to heavy rainfall and high relative humidity. These factors alone effect the performance and serviceability of

instruments and in addition furnish ideal conditions for the growth of microorganisms (fungi, actinomycetes, and bacteria) which collectively attack a wide range of basic materials.

In the course of the research about 4,500 fungus cultures, and 1,100 bacteria cultures were collected from tropical countries and islands for experiment and study. Elaborate laboratory and field studies, particularly in Panama, were carried out.

Though many problems were solved only partially (the work is being continued by the Army and Navy), several positive remedies were discovered and a large body of background information was accumulated.

For example, an adequate method for controlling fungus growth within optical instruments was developed. The method consists of applying a mixture of 50 percent of the fungicide "Cresatin" (metacresyl acetate) and 50 percent ethyl cellulose enclosed in a small aluminum capsule with minute openings. The capsule is cemented within the instrument out of the path of light rays. Under drastic conditions in the Panama jungle the capsule prevented deterioration on binoculars for 21 months.

Practically no information on the tropical deterioration of plastics existed prior to the war, the report states. It has now been well established that fungi surface growths on plastics used in electrical equipment affect the electrical properties of the plastic. However, the effect on the physical and mechanical properties of plastics requires further elucidation.

A fungicidal treatment for film negatives was developed which shows excellent promise and it has also been shown that a cautious use of lacquer containing the mercurial fungicide "Merthiolate" is effective in controlling deterioration of camera parts.

The report summarizes results of tests on flying clothing, airplane fabrics, fruit bars, shoes, stitched leather, filter papers, sheet insulating materials, plastic terminal strips, gas masks, cotton fabrics, paper pads, bridged and steel panels of strippable coating, ear wardens, neoprene earphone sockets, spray coatings, cork samples, glass cord plastics, hookup wires, lenses, felt, and other materials.

An analysis of the problems, the scope of the research, tests methods, and comprehensive discussions of problems connected with resins, photographic equipment, electronic equipment, textiles, and optical instruments are included. A bibliography of detailed reports on wartime research in the field is appended. Several of the detailed reports are available from OTSA, and a list of reports—Bibliography of Reports on Deterioration—is available free of charge.

Orders for the summary report (PB-81801; Tropical deterioration of equipment and materials; $3.50) should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C., and should be accompanied by check or money order, payable to the Treasurer of the U. S.

German Friction Brake Linings

GERMAN FRICTION BRAKE LININGS were made with a strong zinc alloy wire reinforcement according to a report on German asbestos products. The zinc alloy wire was appreciably stronger than the pure zinc wire familiar to the British investigators who studied this industry. The report, covering 10 manufacturers of asbestos textiles, gaskets and friction linings, was prepared by the British Intelligence Objectives Sub-Committee. The zinc alloy wire used in woven brake linings contained 1.1 percent copper 0.8 percent aluminum and traces of iron, lead and chromium. The alloy has higher tensile strength than pure zinc but is less ductile.

German brake linings were in general found inferior to American and British products. Because of wartime shortages of long staple asbestos, most linings were molded with phenol-formaldehyde resins or with buna rubber. In addition to short staple reclaimed asbestos, filled materials included cellulose fibers, slag wool, glass silk, steel wool and brass and other metal particles. Aircraft brake linings were usually molded of steel wool and buna rubber. No wartime substitutes were considered equal in performance to linings made of long staple asbestos.

The British investigators were not impressed by the quality of the high pressure gaskets seen in five of the asbestos firms visited. A certain amount of natural rubber was put into almost all compounds, in spite of Germany's severe wartime shortage. Other ingredients used included buna rubber, asbestos of various qualities, barytes, sulphur, magnesium oxide and zinc oxide.

German experts had high regard for spun glass as a substitute for asbestos in heat insulation and electrical insulation tapes. Production was highly developed, according to the investigators.

Orders for the report (German asbestos textile, jointing and friction lining industries; PB-63873; photostat, $3; microfilm, $1; 36 pages) should be addressed to the Office of Technical Services, Department of Commerce, Washington 25, D. C., and should be accompanied by check or money order, payable to the Treasurer of the U. S.

DISCUSSIONS AND COMMENTS FROM READERS

Hot-Cold Pipe

To the Editor:

On page 173 of the September, 1947 issue there appears a description of a "Hot-Cold Pipe" under investigation by Westinghouse Research Engineers.

You may be interested to learn that the device was patented in the United States by G. J. Ranque of Montlucon, France, on March 27, 1934. The original application was filed in France in 1931, whereas you credit the invention to a German, R. Hilsch.

Copies of the American patent, No. 1,952,281, can be obtained from the United States Patent Office. The date of application in the United States was December 6, 1932. —LOUIS E. SHAW
Newark, N. J.

Fluid Flow Friction Factors

To the Editor:

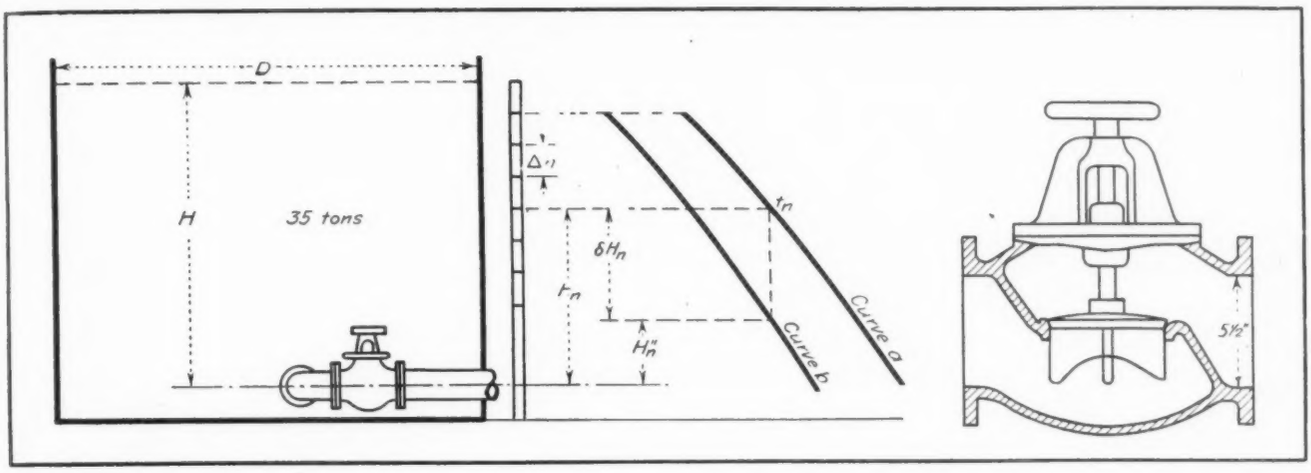
In V. L. Streeter's article "Fluid Flow Friction Factors", July, PRODUCT ENGINEERING, I regret to note that no particulars on the sizes of valves and fittings are published. From observation of the high values of resistance coefficients given in the Table I for valves and fittings it is evident that their sizes did not exceed 2 in. After examining carefully the tabular data, I believe that some further test data on valves of different sizes is of interest.

A. Tests of small globe valves by the Hydraulic Laboratory of St. Petersburg Politechnicum.

Velocity of Water, ft per sec	Resistance coefficient K	
	1⅛ in. valve	2 in. valve
1.31	8.60	7.43
2.62	8.68	7.43
3.93	8.77	7.30
5.24	8.80	7.08

For globe valves Mr. Streeter gives a value of 10 for K. This value of K is greater than the test data cited by from 13 to 16 percent for a 1⅛ in. valve, and from 34 to 41 percent for a 2 in. valve.

B. Tests of 5½ in. globe valve by the



Baltic Navy Yard in St. Petersburg. General arrangement of discharge tank and valve is shown in drawing above.

Velocity of Water, ft per sec	Values of K, Pressure on disk	Pressure under disk
4.03	4.58	5.68
5.11	4.62	5.88
5.87	4.63	5.99
6.58	4.58	6.11
7.22	4.60	6.13
7.80	4.66	....

Differences from Mr. Streeter's data are 114 to 118 and 63 to 76 percent respectively.

C. Tests of valves at Vickers Navy Yard in Barrow-in-Furness.

(a) 4½ in. globe valve, pressure on disk, velocity of water 10.8 ft per sec, K equals 5.0.

(b) 6 in. gate valve, fully opened, velocity of water 12 ft per sec, K equals 0.08.

(c) 6 in. angle valve, pressure on disk, velocity of water 11.4 ft per sec, K equals 1.758. (Mr. Streeter gives K equal to 5, an increase of 185 percent.)

(d) 10 in. Kingston valve, pressure under disk, velocity of water 8.27 ft per sec, K equals 2.85.

D. Tests of 2 in. gate valve at Skoda Works. Valve fully opened, mean water velocity 5.7 ft per sec, K equals 0.15.

Finally it may be mentioned, that in the general Fanning's formula of frictional resistance in pipes, the dependence of frictional factor f from absolute dimensions of pipes is neglected by Mr. Streeter. Actually for a 2 in. pipe and 2 ft per sec velocity of water flow, Fanning gives f equal to 0.0301. For 10 in. pipe and 15 ft per sec velocity, f equals 0.02, that is, a 50 percent lower value.

From these examples it can be concluded, that using data published by Mr. Streeter will result in uneconomical piping design. Moreover, considering compound pipe line design, a poor distribution of water volume from main to branch pipes might be expected.

VICTOR TATARINOV
Consulting Engineer

To the Editor:

I thank Mr. Tatarinov for his comments regarding "Fluid Flow Friction Factors" and for the additional data that he has given on tests of European valves.

European valves are of different design than those in this country. Dr. Bruno Eck, in his book Technische Strömunglehre gives the coefficient of 3.9 for a globe valve with a stem perpendicular to the pipe axis. He also lists other valves, some with inclined stems, having coefficients varying from 3.4 to 0.6. The valve data listed in Table I has been compiled by the Crane Company, and they have selected these representative K values as being conservative for use in pipe design. It is felt that, in general, a more satisfactory design will be obtained by using conservative values than by using values that may be too small for the particular application. For compound pipe line design, in general, the variation in these coefficients should not appreciably affect the distribution of water volume from main to branch pipes.

The friction factor, f, for pipes, is known to depend upon the relative roughness of the pipe wall, that is, the absolute roughness divided by the diameter of the pipe, and upon the Reynolds number. The Reynolds number, of course, takes into account the variations of f with viscosity and velocity of flow for a given pipe size and type.

With reference to Mr. Tatarinov's diagram showing the valve test set-up used for the 5½ in. globe valve for the Baltic Navy Yard tests in St. Petersburg, it is to be noted that the valve is immediately preceded by an elbow. The results of these tests could only be expected to be valid under same conditions of set-up for other installations. The velocity distribution is so disarranged that it would easily effect the loss through the valve by 50 to 100 percent. In using these results, the elbow should also be oriented in exactly the same way, as shown in the figure.

—VICTOR L. STREETER

Temper Designation for Aluminum and Its Alloys

To the Editor:

Rapid metallurgical advances and improved fabricating techniques, during the past few years, have served to magnify the inadequacies of the present Alcoa temper designation system for aluminum.

One example of how the present system is unable to fulfill current requirements is found in alloy 24S, the most widely-used wartime aircraft material. Government specifications recognize the fact that 24S-T flat sheet has higher properties than may result from heat-treating a formed 24S-T part. Under the present system, however, designers have no way of distinguishing on the drawing boards what kind of 24S-T they mean.

Other examples requiring need for a better temper designation system are found in the other forms in which aluminum is fabricated including extrusions, tubing, wire, rod and bar, forgings, rivets and castings.

In order to overcome such inadequacies in the present system and also to provide a definite pattern for future developments, a revised system of aluminum alloy temper designations has been developed by Alcoa. This new system, based on manufacturing techniques, becomes effective on all Alcoa shipments made on and after January 1, 1948.

—DOUGLAS B. HOBBS
Aluminum Company of America

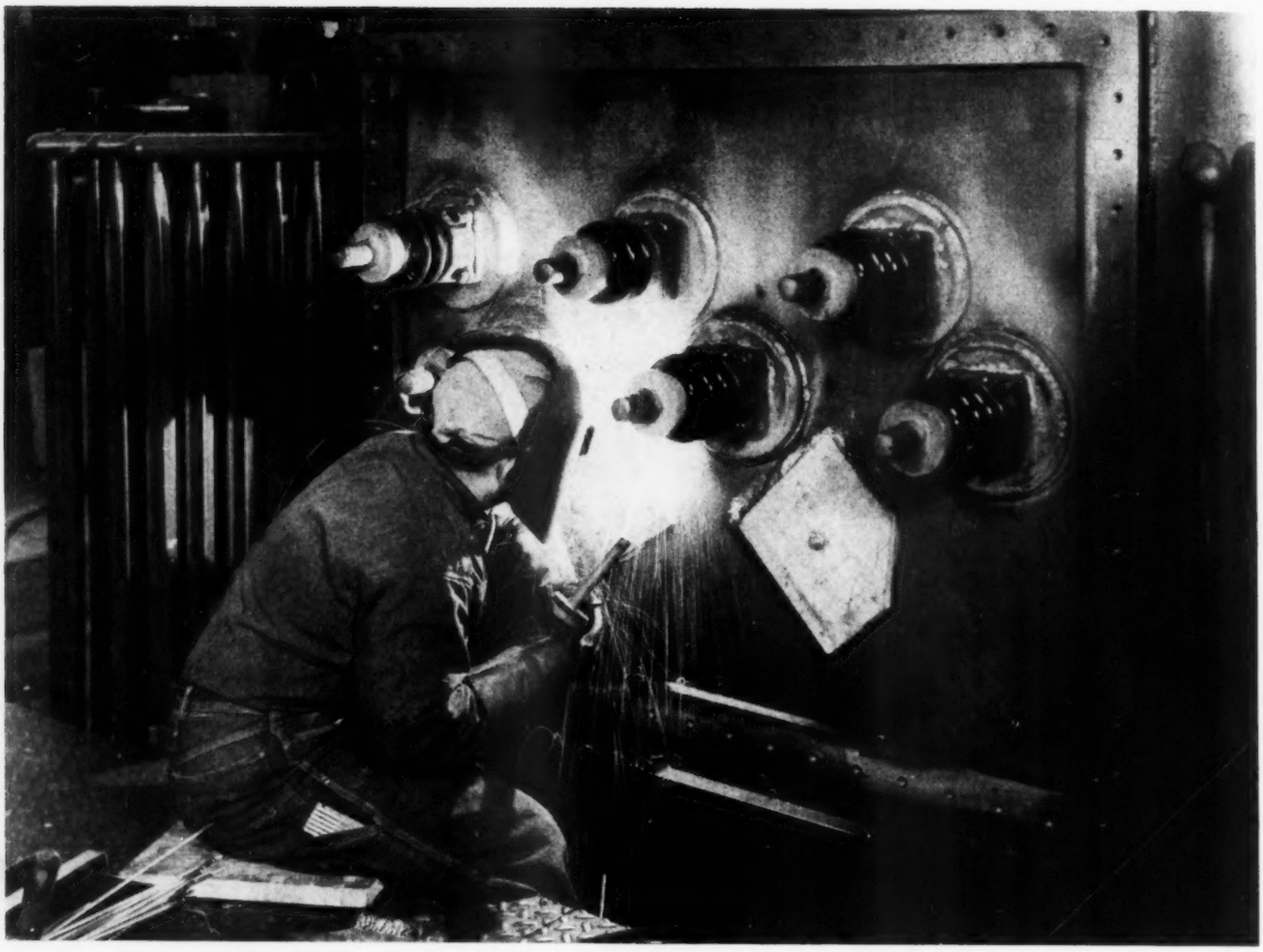


Fig. 1—Arc welding solder seal bushing in the wall of a tank, thus providing gas-tight joint between the ceramic and metal.

Soldered Ceramic-to-Metal Seals

A. L. JENNY

Works Laboratory, General Electric Company

Design facets of a relatively simple and little known type of gasketless seal for making gas-tight joints between ceramic and metal.

A PROMISING but little known type of gasketless seal for many industrial products is the soldered ceramic-to-metal seal now used for cable terminals, bushings and connectors. Such a seal, as shown in Fig. 1, provides an inorganic oil and gas-tight joint between ceramic and metal. The seal is simple in construction and by the use of correct design details such as shown in Fig. 2 it is readily applicable to many joints now using gaskets.

Ceramic-to-metal sealing is related to the ancient art of decorating fine glass and chinaware with thin, fired-on coatings of precious metals such as gold, silver, and platinum. For industrial application, it is necessary to increase (1) the mechanical strength of the metal-ceramic bond, and (2) the free metal thickness to a reasonable working value so that the metallic coating can withstand the thermal stresses of subsequent soldering operations. Usually metallizing compound for the band is an intimate mixture of finely ground noble metal and a synthetic flux or glass-like bonding agent, combined in a liquid resin. Silver is often an effective metalizing element. By the addition of thinner, the viscosity of the mixture can be adjusted for brush, squeegee, dip, spray or wheel application.

Typical Application

A typical industrial application is the fabrication of electrical porcelain for solder sealed insulators. Although "dry pressed" porcelain is too porous for satisfactory solder seals, cast and extruded porcelains are suitable. As background for designing parts for ceramic-to-metal seals a brief sum

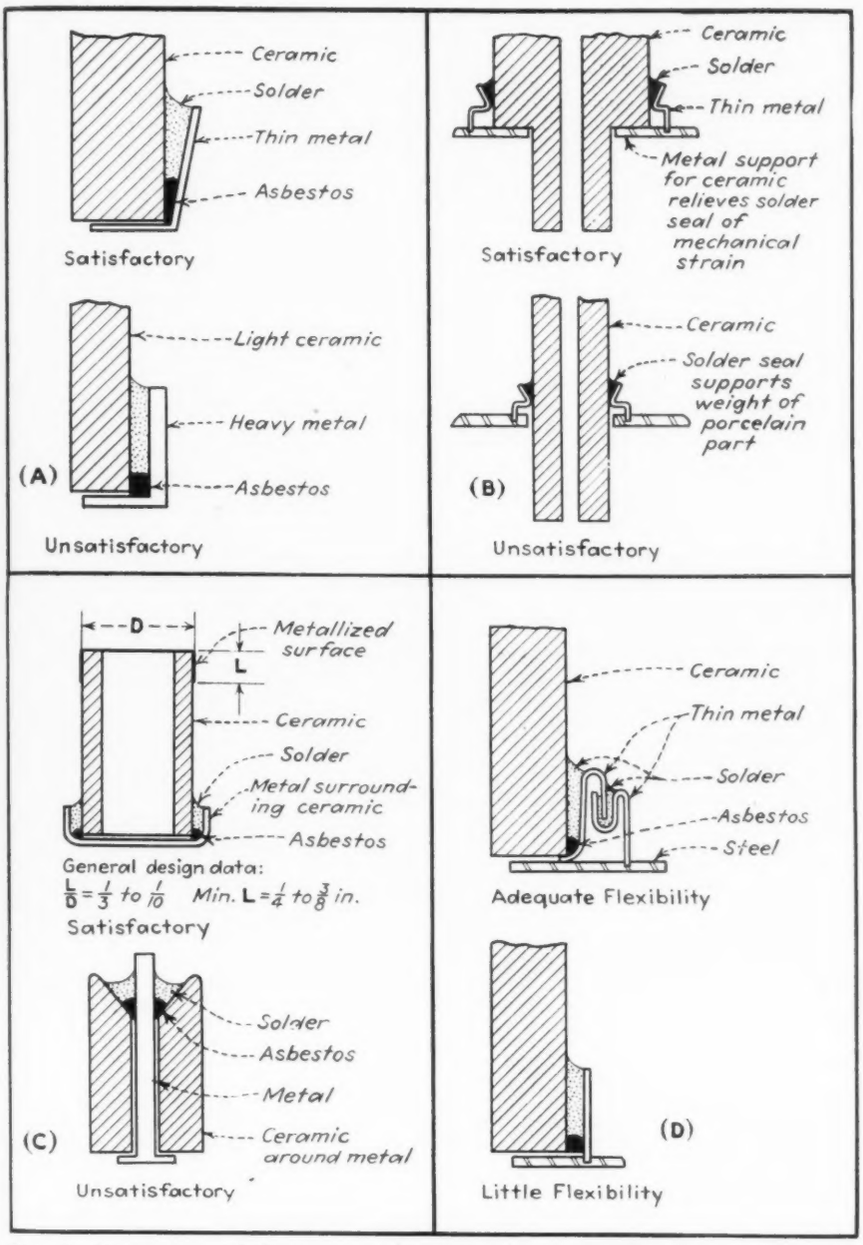


Fig. 2—Comparison of design considerations showing satisfactory and unsatisfactory details. (A) Compared to the porcelain, metal parts should be thin. (B) Design joint so solder seal does not carry mechanical load. (C) Metal should surround the ceramic so shrink-fit favors seal tightness. (D) Provide adequate flexibility. By proper design, such seals are useful in many types of joints.

mary of the latter process follows. In the process, the porcelain ingredients of fine china and ball clays, feldspar, and flint, are blended and mixed. Water is added to make a clay "slip" that is filter pressed and adjusted in moisture content to impart desirable forming characteristics. In the pugging process, which is usually used for seals, the plastic clay mass is extruded through dies under mechanical pressure. Often vacuum is applied simultaneously to exclude air and increase the density.

The extruded blanks are cut into sections and moisture is removed from them in ovens under controlled heat and humidity conditions. The green, or unfired, blank then is placed on a lathe and "machined" to the desired unfired dimensions by a series of cutting tools guided by a template. Scrap porcelain from these cutting operations is captured by powerful exhausts and is continuously fed back on a belt conveyor to reworking tanks.

The formed parts then receive a spray or dip coating of silicate glaze, which on firing imparts a characteristic smooth, brilliant and highly reflective surface to the insulator. Glazed articles are carried through long kiln on slow moving cars for complete curing and vitrefication.

Metal glaze then is applied to specified areas of the fired insulators; the banded insulators then are refired to bond the metal to the ceramic. During this reheating, the flux bond gradually softens as the temperature increases, and begins to react with the silicate glaze ingredients. At the same time, the flux partially dissolves and so anchors metallic particles, forming an integral bond from metal to ceramic as shown in Fig. 3. This thermochemical reaction is carried out in electrically heated, temperature controlled furnaces in oxidizing atmospheres. Reducing gases cannot be used since they produce a weak, temporary union of metal and ceramic that is easily destroyed in subsequent operations.

Essentially a Film

Although the metal film on the porcelain is much thicker than the decorative variety, it still is essentially a film and not solid metal. The small amount of metal and its character is such that it is easily absorbed metallurgically by alloying with molten tin from soft solder.

To prevent alloying, soldering is

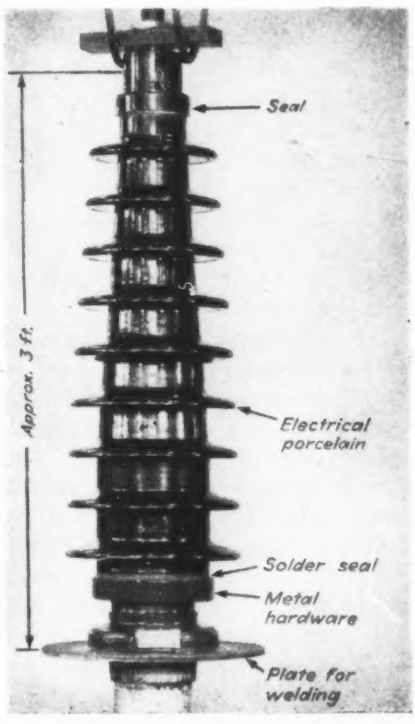


Fig. 3—Typical bushing with the electrical porcelain solder-sealed to metal.

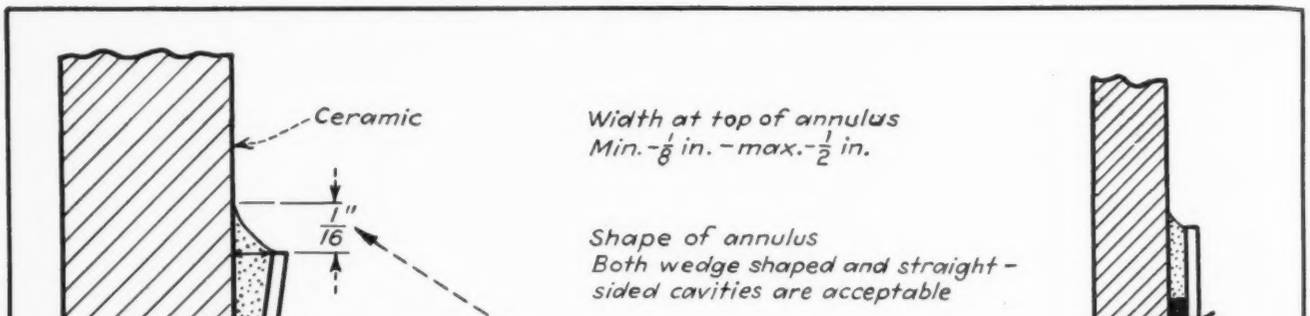


Fig. 4—Design pointers for shape and width of annulus. Length of metallized ceramic should exceed hardware part.

done quickly and with minimum heat. For example, (1) using silver-bearing soft solder lessens the alloying between silver and tin by partially presatisfying the molten tin's ability to absorb silver and (2) maintaining the soldering iron just slightly above the fluid temperature of the solder reduces excess heat and the rate of alloying, thus lengthening the assembly time.

Since neither method is solely practical or economical with large sections usually a metal barrier is interposed between the molten solder and the precious metal by electrodepositing a film of copper over the silver. This prevents direct contact with molten solder but provides a metallic surface that is less subject to attack than the silver and readily solderable. Pre-tinning, or hot solder dipping portions of the metal hardware and ceramic that are to be jointed by solder has proved effective. Pretinning builds up the heat content of parts and locates the initial supply of solder.

Solder sealing of ceramics and metal components is quick since it requires only the placing, melting, and freezing of the solder. In one application, parts to be joined are positioned carefully in a jig, heated, and then slowly immersed in a pool of molten solder that flows into the cavities to be filled. Thermostatic control avoids excessive solder temperature. This type of assembly requires considerable time to remove excess solder from hardware parts and jigs and is best suited to light simple shapes. With heavy sections, assembly time is increased by slow cooling and setting resulting from the heat capacity of the large jigs. This method should not be used for hardware parts that are complex in shape with cavities or undercuts that solder might fill, or parts that are highly machined or have threaded portions. For relatively inaccessible joints, melting wire solder into place with a torch or iron usually forms a good seal.

Small Parts

In the production of small units, composed of hardware parts of thin gauge and small joints requiring only a minimum of solder, the melting of preformed solder rings by induction heating often gives good results. Simplicity of construction and symmetrical contour are necessary when this method is used.

Molten solder can be poured from a ladle into the cavity or annulus between the metal and the ceramic. For large diameter insulators with encircling hardware, for example, this annular space may assume considerable width as shown in Fig. 4. Electrical porcelain usually carries a tolerance of ± 3 percent, and metal parts are designed to fit the maximum allowable porcelain diameter. Thus a nominal 6 in. dia. porcelain might vary in diameter from 5 13/16 in. to 6 3/16 in., and the inside hardware diameter at the seal, assuming a 1/8 in. wide annulus, would be 6 5/16 in. The annular space then might vary in width from 1/8 in. for a maximum diameter porcelain to 1/2 in. for a minimum diameter porcelain. To conserve solder in such instances, the joints are partially packed with asbestos or some similar material.

Sometimes units can be soldered in a conveyor type oven. For example, this method is best suited for soldering a plurality of bushings to a common hardware part.

Shrink Fit Effect

In soldered ceramic-to-metal seal construction, the component parts have the following widely different coefficients of thermal expansion in the range 0 to 200 C.

Material	Expansion in./in./C × 10^{-6}
Electrical porcelain	3.5–5.5
Solder	25–35
Steel	9–11
Copper	17–18
Brass	17–18
Si-bronze	17–18

Because of this difference in rate of expansion of the components the hardware exerts a continual residual compressive stress on the ceramic part through the solder. This condition is analagous to the shrink fit of a metal rim on a wooden wagon wheel or "hoop tension". Stress equilibrium exists when the charge of molten solder is first placed in the annulus between metal and ceramic. But as soon as the solder sets and the assembly begins to cool, the compressive forces appear and reach a maximum when thermal equilibrium has been attained.

The compressive force is advantageous, since it obviously favors seal

tightness. However, the circumferential tensile stress developed in the metal part may exceed its elastic limit. Having acquired a permanent set, a reduction in the compressive stress on the ceramic occurs even when the elastic limit is not exceeded immediately. A soft copper part may creep over an extended period and thus increase the possibility of leakage. To lessen the relaxation of hardware parts high-endurance limit alloys could be used such as silicon bronze, stainless steel or beryllium copper. But tests indicate that the strength of the seal is relatively independent of the type of metal hardware used, as shown in Table I. Threaded brass bushings were brazed to the seal cap applying the tensile load.

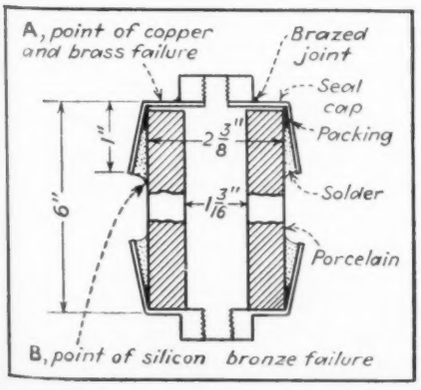
Seal Is Strongest Part

These seals were pressure tight before the mechanical test, and all ceramic metal joints remained intact throughout the test. The tensile load was distributed over a metallized area on the ceramic of seven square inches, so that at rupture a maximum shear stress in excess of 500 psi per seal existed at the ceramic-metal interface. These tests show that a ceramic-metal seal can be made that is stronger than the metal hardware part or stronger in tension than the porcelain itself, depending upon the physical properties of the metal part used. With an adequate area provided for the ceramic-metal joint, the seal-design limits are the type and gauge of metal parts and the porcelain's tensile strength.

Table I—Comparison of Rupture Characteristics of Three Kinds of 0.060 in. Thick Metals

Metal	Average Rupture Load, psi	Point of Rupture
Copper*	2,750	At *A* in metal near
Yellow brass*	3,450	At *A* brazed joint
Silicone bronze	3,857	At *B*, in porcelain

*Hardware distorted considerably before rupture.



Experience in the joining of ceramics and metals by other than soldering has shown the necessity of avoiding heavy metal hardware unless adequate cushioning is provided. At very low temperatures, such as — 70 F, a copper flange may crush and break a porcelain tube having a wall thickness ten times the metal thickness. At below zero temperatures, solder is a very sluggish cushion. The seal problem for low temperature that is often present in outdoor applications, discourages the use of high endurance alloy parts, since the compressive effects of the two are cumulative.

Overall design economy of desirable cold seal construction reduces to thin, soft copper hardware parts with an adequate joint area. A seeming disadvantage of this cold-seal assembly occurs when it is suddenly subjected to prolonged heating. The metal parts reach top temperature far in advance of the ceramic; thus the rapid expansion reverses the stress on the ceramic from compression to tension of several hundred pounds.

To evaluate the ceramic-metal joint in pure tension, porcelain briquettes similar to those used in determining the tensile strength of cement-sand mixtures have been sawed in half, metallized, and rejoined by soldering. Such joints have been shown to be stronger than the ceramic body itself and have a tensile strength in excess of 1,500 psi. Copper, steel and brass half-briquettes have been substituted for one of the porcelain halves with similar results. A joint-strength superior to the ceramic body itself in tension is certainly satisfactory. The tension condition in seals having thin hardware is essentially a mental hazard that can be factored out by adequate design of the particular seal.

Table II—Comparison of Rate of Creep of Solder

Composition of Solder, Percent	Time to elongate 0.5 percent, min.
50 tin—50 lead	9
40 tin—60 lead	30
60 tin—40 lead	35
40 tin—58 lead—2 silver	40
30 tin—59 lead—1 silver—10 bismuth	60
20 tin—79 lead—1 silver	700
30 tin—66.75 lead—1.25 silver—2 antimony	2,400

Specify Right Solder

The choice of the correct solder for ceramic-metal seals depends upon the rather simple requirements of (1) minimum working temperature to eliminate excessive heat shock on the porcelain, (2) minimum porosity to achieve and maintain joint tightness, (3) minimum liquidus to solidus temperature to avoid shrink holes, and, (4) maximum creep.

In design it is not always possible to utilize metal parts thin enough to maintain the desired flexibility of all the seal components, so it becomes important to specify a solder with maximum creep or cold flow at stresses around 1,000 psi. To determine the rate of creep, the various solders listed in Table II were cast in 1/4 in. diameters and machined down to 1/8 in. diameter over a 1 in. long section. Then, at a stress of 1,000 psi the time was measured for each composition to elongate by one half of one percent. Measurements were made at room temperature under conditions that reduced outside vibrations as much as possible. At elevated temperatures the creep rate is more rapid, and stresses are equalized more readily.

Although the 50-50 tin-lead solder fulfills the other requirements of an ideal solder and has the maximum creep rate of 1,000 psi, the solder should never be used to provide mechanical support to other components.

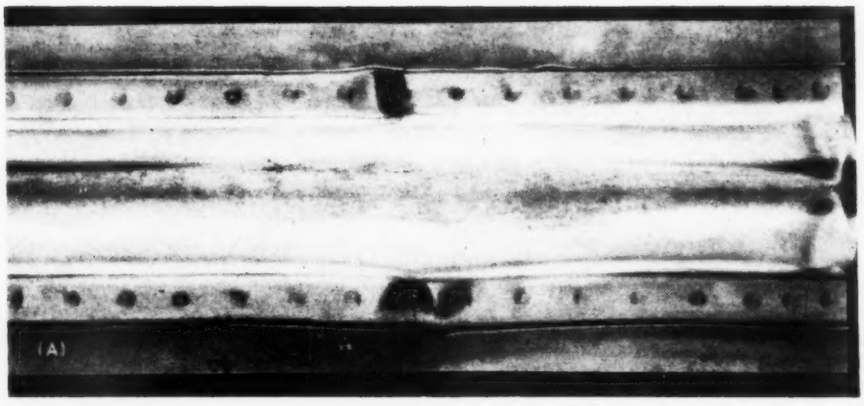
Such mechanical support requires a consideration of satisfactory and unsatisfactory designs, desirable contours and preferred proportioning of parts such as shown in the design details. Note that asbestos packing at the base of the cavity, for example, provides a cushion and prevents chipping the sharp corners of the porcelain.

Spot-Welded Aluminum Components Designed for Repeated Loads

ROBERT C. McMASTER and HORACE J. GROVER
Battelle Memorial Institute

Results of two separate series of tests. One series to investigate the effect of spot welded connections on the static and fatigue strength of stiffened panels in compression. The other series to investigate the effect of spot welds joining stressed and unstressed attachments to tension members.

TESTS to determine the effect of spot welding on the compressive and tensile fatigue strengths of various types of structural components of 24 S-T Alclad aluminum alloy were conducted by the Battelle Institute during the war. These tests included the investigation of the strength of spot welded lap joints, sheet and stringer combinations, and attachments. Design data obtained from the results of tests on lap-joints were published in a preceding article (see PRODUCT ENGINEERING, November, 1947, p. 112). Further data on sheet and stringer combinations and attachments are presented here. The object of all tests was to survey fatigue behavior of aircraft structural components manufactured according to current shop practices and welding techniques rather than to attempt to determine the effects of the variables in welding procedure.



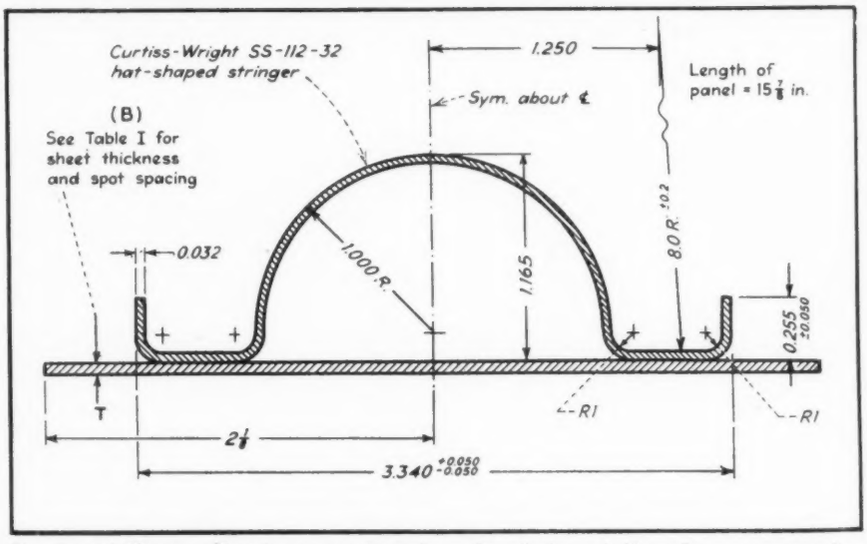


Fig. 1—(A) Sheet and stringer combination after fatigue failure from compression loading. (B) Dimensions for all sheet and stringer combination specimens.

Stiffened Panels

Sheet sections, particularly in aircraft design, are often stiffened against buckling by hat-shaped ribs. Figs. 1(*A*) and 1(*B*) illustrate and give the dimensional details of the test pieces. Table I furnishes information on the static compressive properties of the test specimens, including the hat-shaped stiffener alone.

Each fatigue test specimen was held in a Krouse testing machine with ends fixed so that the center of mass of the specimen was on the axis of loading. The majority of the tests were made at a ratio of minimum compressive load to maximum compressive load of + 0.25. The criterion of failure in these tests was the breaking away of any spot weld to such an extent that the panel at that point was completely free from its stringer. A failure of this type usually caused a change in load sufficient to actuate the cutoff mechanism of the machine.

From stress-cycle graphs the curves of Fig. 2 were plotted, which show the variation in strength with sheet gage for panels having spot welds 1¼-in. apart. The curves indicate that: (1) The stress at fatigue failure for lifetimes up to one million cycles or less is greater than the buckling stress; (2) the crippling stress decreases with increasing panel thickness whereas the buckling stress increases for the range of thicknesses tested;

Table I—Sheet Thicknesses, Spot Weld Spacing and Static Strengths Of Sheet and Stringer Combination Test Specimens

Type No.	Sheet thickness, in.	Spot weld spacing, in.	Area A,* sq in.	Average buckling load P, lb	Average buckling stress P/A, lb per sq in.	Crippling load Q, lb	Crippling stress Q/A, lb per sq in.
Stiffener alone.....	.....	....	0.162	.....	.....	5,680	34,400
Sound welds							
1	0.025	0.75	0.275	1,750	6,360	8,400	30,500
2	0.025	1.25	0.275	1,750	6,360	7,940	28,900
3	0.032	0.75	0.306	2,950	9,630	9,020	29,500
4	0.032	1.25	0.306	2,950	9,630	8,300	27,100
5	0.032	2.00	0.306	.....	5,720	.....	26,100
6	0.040	0.75	0.342	3,900	11,400	10,445	30,500
7	0.040	1.25	0.342	3,900	11,400	8,640	25,200
8	0.051	0.75	0.391	4,600	11,800	11,160	28,500
9	0.051	1.25	0.391	4,600	11,800	9,520	24,400
Overheated welds							
10	0.025	0.75	0.275	1,650	6,000	8,650	31,500
11	0.025	1.25	0.275	1,700	6,200	8,175	29,800
12	0.032	0.75	0.306	3,000	9,800	9,000	29,500
13	0.032	1.25	0.306	2,850	9,300	8,550	28,000
14	0.040	0.75	0.342	3,300	9,650	9,650	28,200
15	0.040	1.25	0.342	4,000	11,700	8,600	25,300

*Total area of stiffener, 0.162 sq in., plus sheet

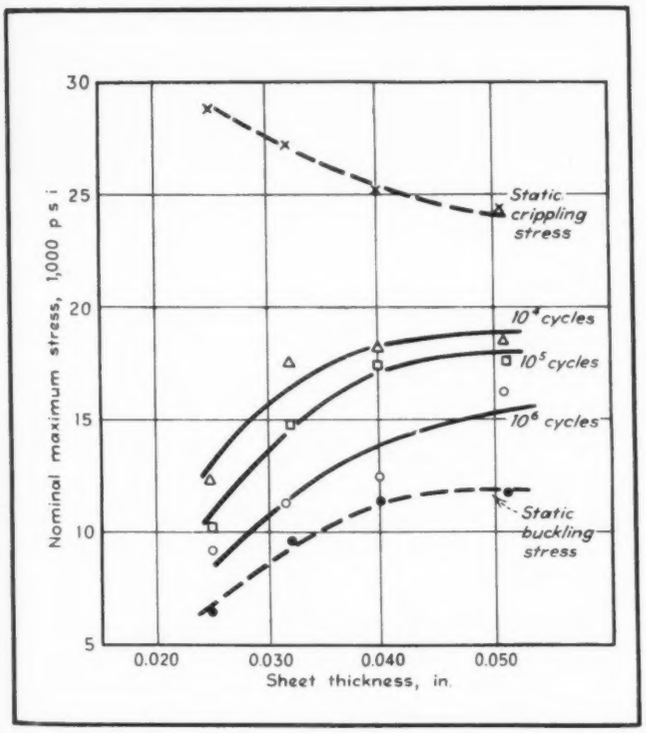


Fig. 2—Compressive strength of sheet and stringer combination with 1¼ in. spacing as function of sheet thickness.

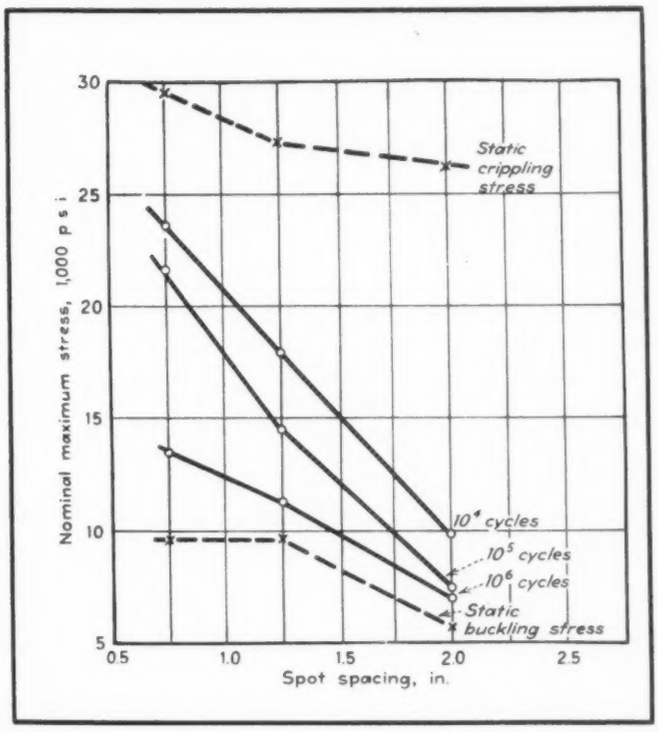


Fig. 3—Compressive strength of sheet and stringer combinations (0.032 in. sheet) as function of spot weld spacing.

accordingly, fatigue strength seems to be more closely correlated with static buckling strength than with static crippling strength.

To check the effect of weld spacing on the compression fatigue strength of sheet and stringer combinations, tests were run on a number of specimens made with 0.032 in. hat sections and 0.032 in. sheet. The results are shown in Fig. 3. Although the data used are too limited for generalization, it is evident that increased weld spacing increased local instability.

Three types of test pieces were used to determine the effects of spot-welded attachments: (1) The Monoblock sheet specimen, Fig. 4(*A*), for testing tensile fatigue properties of the material in the absence of spot welds. (2) the tensile fatigue sheet specimen, Fig. 4(*B*), to which a strip 1-in. wide was attached by a single row of spot welds. This style is referred to as the "unstressed attachment" because the strip itself was unstressed by the loading. (3) In contrast, the "stressed-

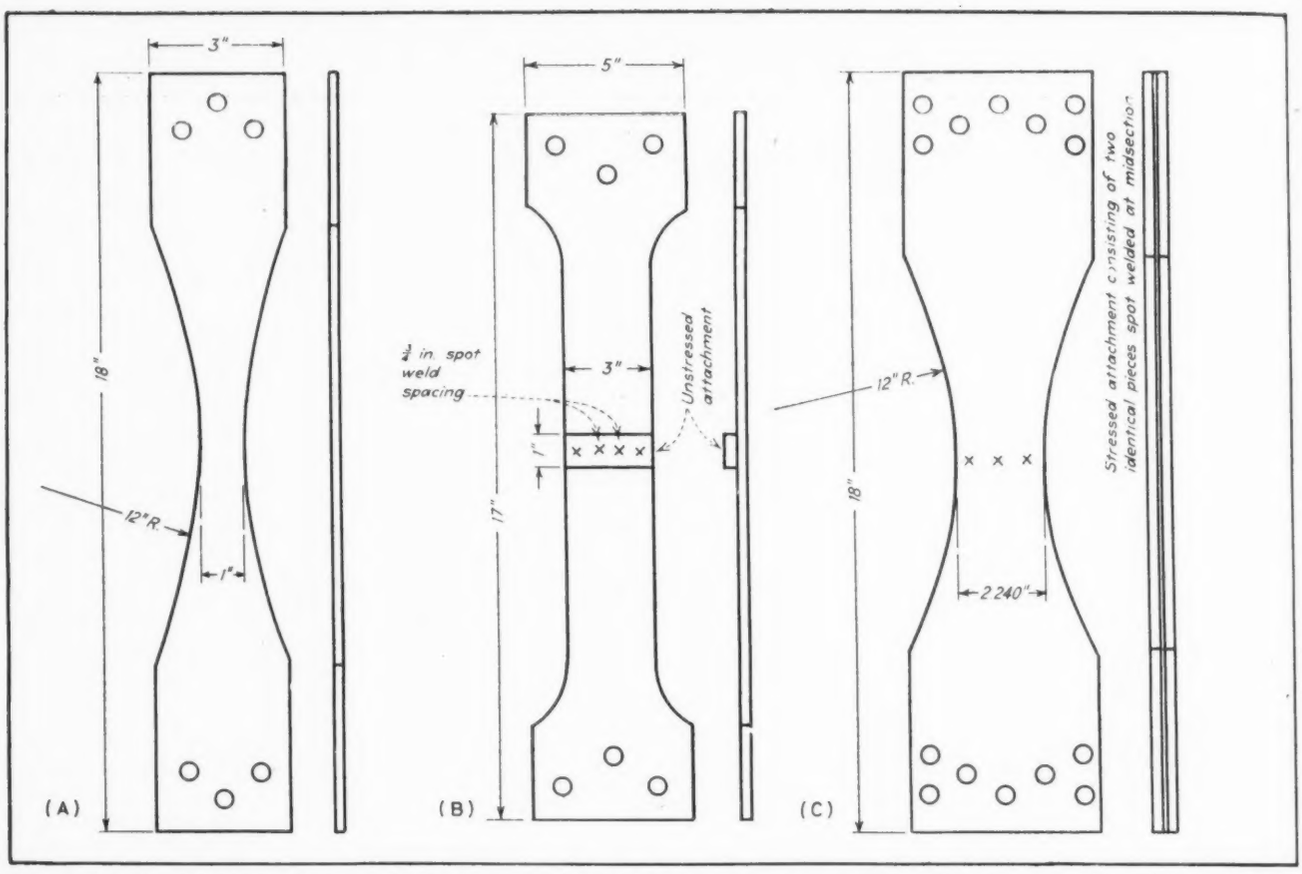


Fig. 4—(A) Monoblock specimen. (B) Specimen used for testing effect of unstressed attachment. (C) Specimen used for testing effect of stressed attachment (B) and (C) simulate two types of connections used in aluminum sheet construction.

attachment" specimen, Fig. 4(*C*), consisted of two identical pieces of sheet spot welded together at the middle. The object during testing was to load both pieces equally. Except for errors resulting from inequality of loading the two components of the stressed attachment specimens (in which a differential load of less than 6 percent was introduced) none of the attachments transferred a load to the tension sheet undergoing observation.

UNSTRESSED ATTACHMENTS. Spot-weld spacings of 1¼ and ¾-in. were used; hence each unstressed attachment was joined to the tension sheet with either 2 or 4 spot welds. Table II contains the results of static tests on this type of specimen. Fig. 5 shows the results of the fatigue tests. Many of the specimens ruptured at the fillet instead of across the spot welds as intended. This explains why a change in the shape of the specimens was made during the tests from that shown in Fig. 4(*B*) to that of 4(*C*). The latter, in which the cross-section diminished continuously toward the region of the spot welds, always failed through the welds. If the static strengths and elongation of Table II are compared with the average ultimate and yield strengths of 66,900 and 50,400 lb per sq in. respectively, and with an elongation of 19 percent in 2 in., the following results are obtained:

1. The presence of the spot welds reduces the static ultimate strength of the sheet from 9 to as much as 19 percent.

2. Static yield strength is affected but slightly by spot welds.

3. The percent elongation across the attachment is reduced by the spot welds.

Two types of failure were observed for the unstressed attachment test pieces: (1) At high stress under repeated loading, as in static loading, the sheet cracked across the line of spot welds. Metallographic examination showed that cracks usually started at the protrusion of the Alclad into the weld and propagated outward to the surface of the stressed sheet. (2) At low fatigue loads, failure often occurred in the fillet.

Specimens that failed in the fillet

Table II—Sheet Thicknesses, Spot Weld Spacing and Static Strengths Of Test Pieces with Spot-Welded Unstressed Attachments

Sheet gage, in.	Spot weld spacing, in.	Ultimate* tensile strength, lb per sq in.	Yield strength at 0.2 percent elongation, lb per sq in.	Elongation in 2 in. across attachment, percent
0.025	¾	60,800	50,700	7
0.025	1¼	55,800	49,300	5
0.032	¾	56,600	46,800	5
0.032	1¼	54,400	47,900	6
0.040	¾	58,400	51,500	7
0.040	1¼	60,600	48,300	5

*Based on gross area of sheet without attachment. All specimens failed across the line of spot welds.

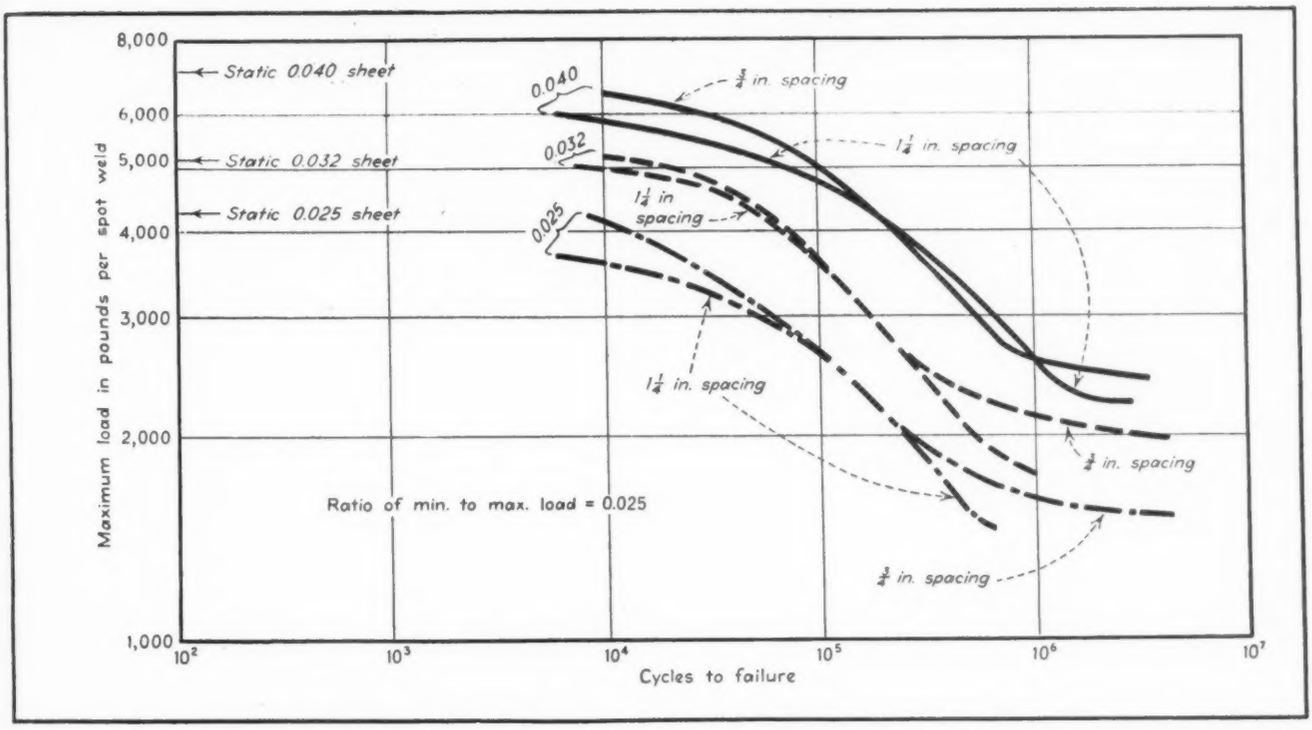


Fig. 5—Tension fatigue strengths for unstressed attachment specimens with variation in sheet gage and spot spacing.

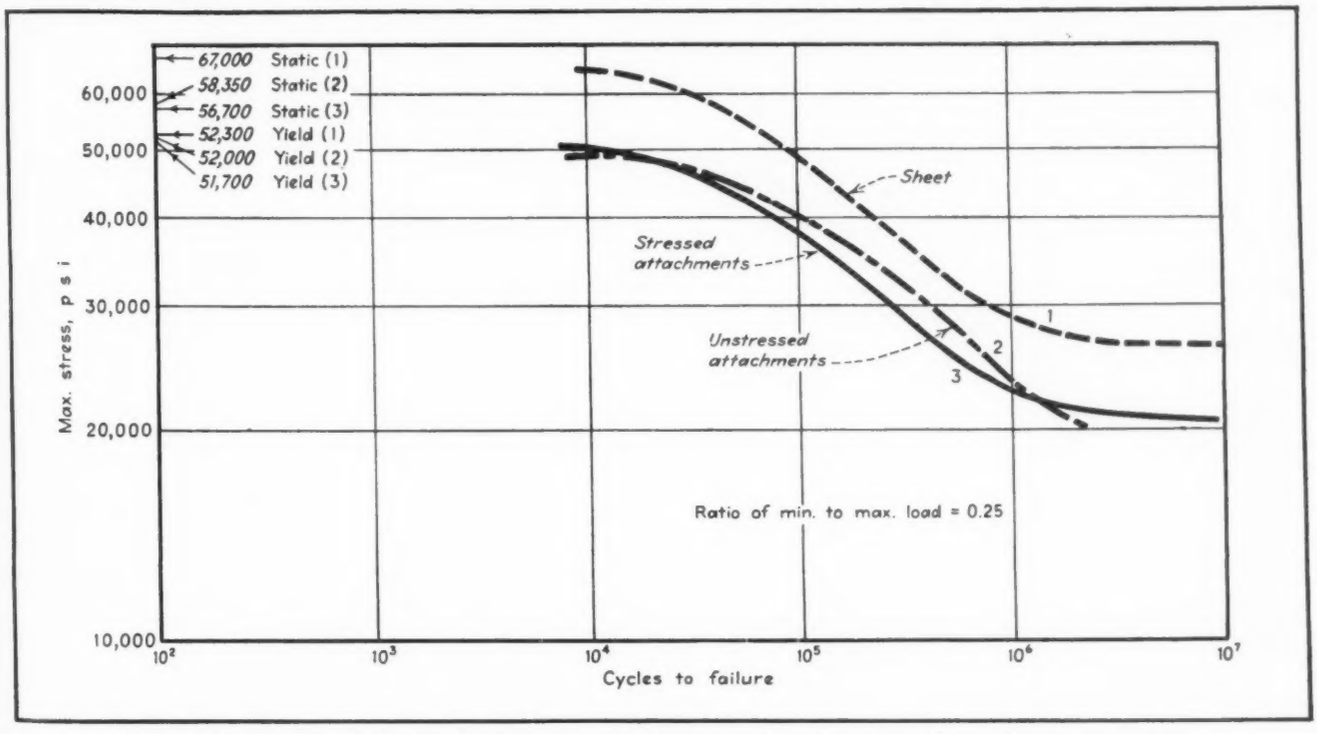


Fig. 6—Comparison of tension fatigue strengths for stressed and unstressed attachment specimens.

sometimes showed incipient fatigue cracks in the spot welds. A comparison of the fatigue strengths observed for these specimens with the fatigue strengths for the sheet material alone revealed that the presence of the unstressed spot-welded attachments did not seriously weaken the sheet in fatigue; Fig. 6, curves 1 and 2 show how the spot welds affect the fatigue strength, being roughly in about the same proportion as the effect of spot welds on the static strength.

STRESSED ATTACHMENTS. Curve 3 shows how fatigue test data from the stressed attachment specimens compare with those from the two other types. The stressed attachment specimens were from sheets of 0.040 in. 24 S-T Alclad alloy joined by a single row of spot welds with ¾-in. spacing. Two sets of specimens were tested: (1) Sheets spot-welded as received, and (2) sheets spot-welded as received but post-aged for 10 hours at 350 F and air cooled before testing in fatigue. The post-aging heat treatment did not improve the long life fatigue strength to any great extent.

NEW BOOKS

Elementary Fluid Mechanics

JOHN K. VENNARD, *Associate Professor of Fluid Mechanics, Stanford University. Second Edition.* 339 *pages,* 5½ *x* 8½ *in. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $4.

The second edition of this introductory book on fluid mechanics is marked by careful reorganization and revision. The original chapter on flow of an ideal fluid has been expanded to three chapters: Flow of an Incompressible Ideal Fluid, Flow of a Compressible Ideal Fluid, and the Impulse-Momentum Principle. The chapter on Ideal Flow in Pipes has been rewritten, and the chapter on Flow About Immersed Objects has been revised with special emphasis on frictional drag. New problems have been added.

Six Place Tables

EDWARD S. ALLEN, *Professor of Mathematics, Iowa State College. Seventh Edition.* 232 *pages,* 4¼ *x* 7 *in. Published by McGraw-Hill Book Co., Inc.,* 330 *W.* 42 *St., New York* 18, *N. Y.* $2.50.

A selection of Tables of Squares, Cubes, Square Roots, Cube Roots, Fifth Roots and Powers, Circumferences and Areas of Circles, Common Logarithms of Numbers and of the Trigonometric Functions, the Natural Trigonometric Functions, Natural Logarithms, Expotential and Hyperbolic Functions and Integrals.

This seventh edition has expanded the tables of Expotential and Hyperbolic Functions to six place accuracy. A marginal index is included. This book will be a valuable mathematical reference for engineers in all phases of design work.

Ferrous Metallurgical Design

JOHN H. HOLLOMON, *Research Laboratory, General Electric Company; and* LEONARD D. JAFFE, *Watertown Arsenal Laboratory, U. S. Ordnance Department.* 346 *pages,* 5¾ *x* 9 *in. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $5.

In this volume, the authors have presented and organized the currently known principles and data that are pertinent to the problem of metallurgical design of steel parts for optimum mechanical properties, to permit intelligent design and to point out those problems that require further study.

Three subjects: Transformations, heat flow, and mechanical behavior; include the field of knowledge upon which metallurgical design of heat-treated parts must be based. Following a discussion of these fundamentals, engineering principles and data are presented for use in designing the combination of heat-treatment and composition that will produce optimum properties in a part. Separate chapters are devoted to the subjects of mechanical properties, quenching, hardenability, quench-cracking, and temperability. A bibliography of more than 300 reference sources is included.

Lessons in Arc Welding

The Lincoln Electric Company. Third Edition. 158 *pages,* 5⅜ x 8½ *in. Published by the Lincoln Electric Company, Cleveland* 1, *Ohio.* 50 *cents.*

This book includes a series of lessons that form the basis of instruction in the Lincoln Arc Welding School. Various types of arc welders are described. Profusely illustrated with photographs and sketches, the mechanical operations for arc welding various types of joints are described.

Properties of the different types of electrodes are described and their applications listed. Physical properties of the welds are given. A series of questions for each of the lessons is included for the use of the instructor and student.

By presenting the fundamental facts of arc welding in a concise manner this book will be an aid to engineers, instructors, students and operators concerned with the mechanical operations and applications for arc welding.

Injection Molding of Plastics

ISLYN THOMAS. 534 *pages.* 9¼ x 6¼ *in., green clothboard covers. Published by Reinhold Publishing Corp.,* 330 *W.* 42*nd St., New York* 18, *N. Y.* $10.

This is a complete discussion of the injection molding of plastics materials, which should prove useful to the product and mold designer, the plant engineer and the plastics technologist. Mr. Thomas is a plastics engineer of broad experience, and his knowledge is reflected in the scope of the book. At the outset the author traces the history and development of injection molding from its inception to the present time. The body of the book is devoted to mechanical details of presses, mold design and operating techniques. Included also are intensive discussions of materials for injection molding, both thermoplastic and thermosetting resins, design of molded parts and design standards for inserts, finishing and decorating, and estimating. Machines, molds and molded parts are well illustrated throughout the volume.

Basic Engineering Drawing

H. D. ORTH, R. R. WORSENCROFT, *and* H. B. DOKE, *all of University of Wisconsin. First edition.* 346 *pages,* 6 x 9½ *in. Published by the Irwin-Farnham Publishing Co., Chicago* 4, *Ill.* $3.50. *Also available: Problems in Basic Engineering Drawing. First edition.* 9½ x 11 *in.* $2.50.

These are a textbook and an accompanying problem book covering the theory and practice of mechanical drawings on an elementary level. The authors do not pretend to cover all the specialized phases of engineering drawing. They begin with a thorough description of instruments and drawing materials, then proceed to othographic presentation and sectional views, endeavoring to present each problem clearly so that the beginning student can master the topic, with little or no assistance from an instructor. Chapter 9 on Shop Processes is unusually well done. Drawings and text are combined to describe casting, welding and machining operations. These excellent drawings clearly show the differences between machine operations.

College Physics

FRANCIS WESTON SEARS, *Professor of Physics, Massachusetts Institute of Technology and* MARK W. ZEMANSKY, *Associate Professor of Physics. College of the City of New York. Part I,* 383 *pages,* 6 x 9 *in. Published by Addison-Wesley Press, Inc., Cambridge* 42, *Mass.* $3.50.

This volume is the first part of a textbook series on College Physics and deals with the subjects of Mechanics, Heat and Sound. The material is suitable for first year college students whose mathematical preparations include algebra and trigonometry. Emphasis is given to physical principles with historical background and practical application given secondary consideration.

The book is well illustrated with sketches that refer to the derivations and problems. Fundamental laws and equations for forces, motion and work are given. Viscosity, temperature and heat are discused.

Practical problems are given at the end of each chapter. An appendix includes four-place tables of common logarithms, three-place tables of natural trigonometric functions and a periodic table. An index and answers to the problems are also given for the benefit of student and instructor.

Application Tables To Guide in the Selection of Materials—II

ZOLA FOX
Engineer, Rocket Section, Curtiss-Wright Corporation

DESIGNERS are often faced with the problem of selecting unfamiliar materials for services not covered by previous experience. They then rely on published experience. In this series, an attempt has been made to reduce the number of references that the designer must study. It is a compilation of present good practice in the whole field of machine design.

The majority of the wrought metals, ferrous and non-ferrous, were listed in PRODUCT ENGINEERING, Nov. 1947, pages 165, 167, 169. The wrought magnesium alloys and the various casting alloys are covered in this set of tables.

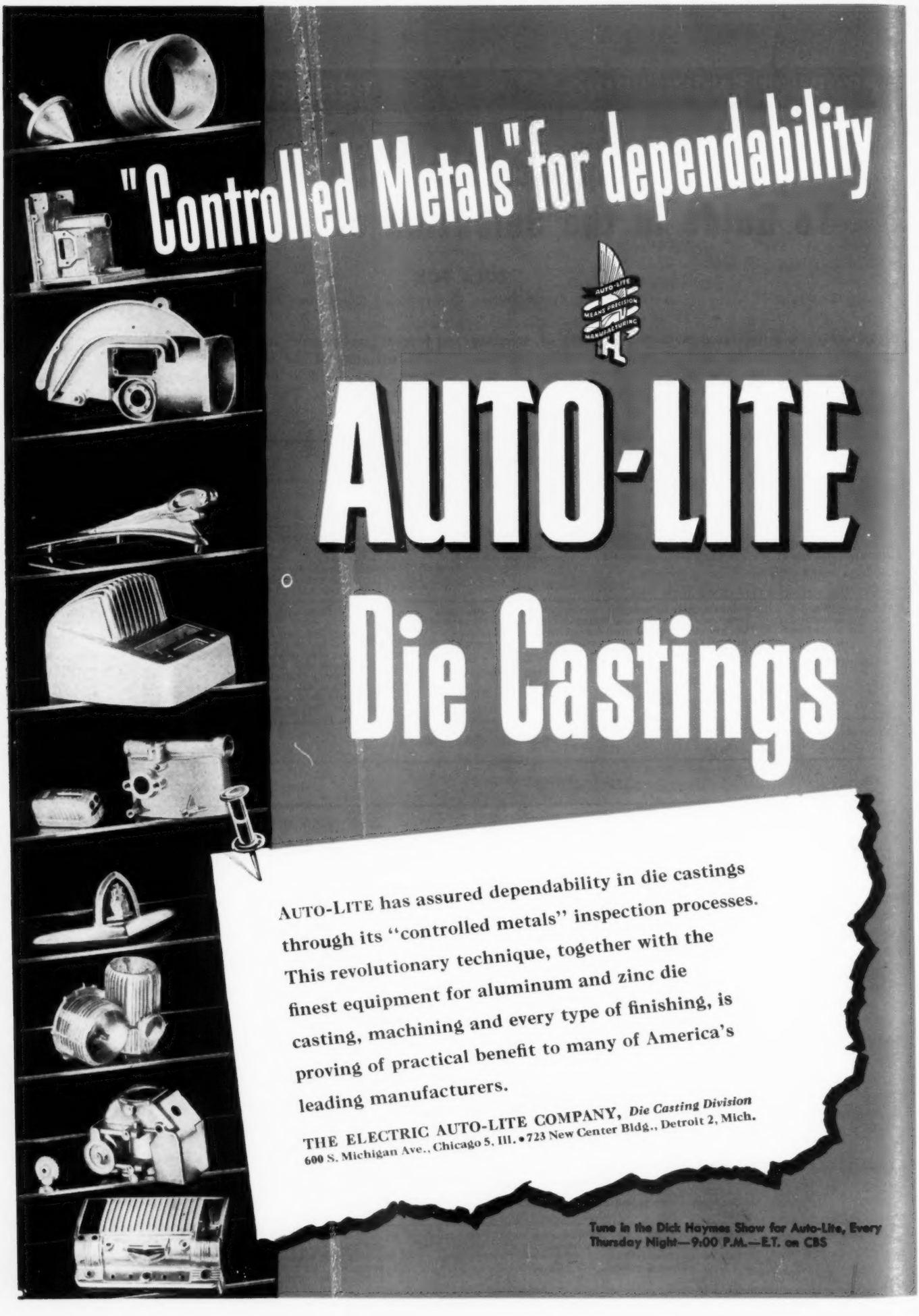
WROUGHT MAGNESIUM ALLOYS

MATERIALS AND USUAL FORMS AVAILABLE	APPLICATIONS	REMARKS
AM 3S–Dow M Sheet, rounds, extruded shapes and forge stock.	Low or moderately stressed, secondary aircraft structural parts, oil and fuel tanks. Furniture and household appliances. Use where welding and very light weight are required.	Good formability, weldability. Good corrosion resistance if properly finished. Excellent machinability. Formability best when heated. Not recommended for use above 400 deg. Low abrasion resistance. For better formability and deep drawing qualities but with lower physical properties and limited weldability, use AM52S or Dow FS-1.
AM 57, 54;–Dow J-1 Sheet, rounds, extruded shapes and press forge stock.	For extremely lightweight, moderately stressed secondary structures and structural fittings where high physical properties are required and good formability and weldability are not. Aircraft frames, conduits, parts in textile machinery, engine cowlings, bus and truck roofs.	Low stiffness with excellent machinability. Hardens rapidly with cold work. Formability greatly improved when heated to about 600 deg. F. Poor abrasion resistance. In forgings, material has marked grain directional properties and low compression yield strength. Slight improvement in properties obtainable with heat-treatment. For slightly higher physical properties substitute AM 58S. For easier forging specify AM352 or 65S. Subject to galvanic corrosion when in contact with steel, brass or bronze. Arc weld only. Readily spot welded. Not recommended for use above 400 deg. F.

FERROUS CAST METALS

MATERIALS AVAILABLE	APPLICATIONS	REMARKS
Cast Iron	For machinery bases, housings, pipes and fittings. For parts that may involve metal to metal wear. Precision bearings, engine cylinder blocks, piston rings, gears, flywheels and pulleys. There are many specialized grades of cast iron for specific purposes to overcome objections to plain cast iron such as: Meehanite, nickel, molybdenum and copper alloyed cast irons.	Cheap, easy to cast. Low strength material. Excellent machinability. Inherently brittle, yet resistant to failure caused by external notches. Susceptible to growth if subjected to cyclic heating and cooling. Good atmospheric corrosion resistance. Excellent vibration damping characteristics. Does not seize or gall. Not generally welded except for repair work, where brazing is widely used.
Malleable Iron	Automotive and agricultural equipment; such as housings, differential carriers, brake shoes, rear axles, miscellaneous brackets, steering gear housings, pedals, links, binder needles and mower shoes. Railroad car castings, bridge railings, pipe and rail fittings. Specify pearlitic malleable iron for parts requiring hardness and wear resistance.	Moderate strength, good shock resistance. More ductile than cast iron though not as wear resistant. Excellent machinability. Not weldable. Unsuitable as a bearing except for low speeds with ample lubrication. For higher strength use steel forgings or castings. Good atmospheric corrosion resistance. Good foundry characteristics, but requires elaborate heat-treatment.
Carbon Steel	Used for economical castings of moderate strength in rolling mill frames, machine housings, connecting rods, links, levers; parts for heavy machinery. Medium carbon type steel most widely used as heat treatment. Results in good yield strength and ductility. Low carbon types may be carburized for hard surfaces.	Lower carbon contents (less than 0.35 percent C) readily weldable; higher carbon contents are welded with difficulty. Heat-treat for improved machinability and physical properties.
Nickel Steel	For cast parts requiring toughness and resistance to impact and repeated stresses. For mining, excavating, mill, locomotive and ship castings, housings and frames.	Has excellent physical properties at low temperatures. Suitable material for applications involving operation at subnormal temperatures. Weldable by all processes. Suited for castings of large section.
Chromium Steel	For castings of good strength requiring hardness, resistance to abrasion, high temperatures and moderately corrosive conditions. For conveying equipment parts, rolling mill rolls, dies, crusher parts, oil refinery equipment.	Good wear resistance. Arc welding generally preferred. When corrosive conditions are severe, cast stainless steel should be specified.
Molybdenum Steel	For large intricate castings which are difficult to heat treat and which require considerable strength and growth resistance at elevated temperatures. For turbine and pump casings, engine blocks, high pressure and temperature valves and fittings.	Heat-treat to obtain good weldability and machinability.
Manganese Steel	For cast parts requiring exceptional wear and abrasion resistance. For parts subjected to repeated impact stresses. Used in tractor treads, excavating buckets, wheels, mining tools, plow tips, railway couplings, mill rolls, sprockets, crushers.	Hard to machine. Heat-treatment improves machinability and greatly improves toughness and ductility. High manganese type is non-magnetic. Welding difficult; electric arc preferred. Do not use unalloyed high manganese type where temperatures exceed 650 deg. F.

(*Continued on page 167*)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AUTO-LITE
Die Castings
AUTO-LITE has assured dependability in die castings through its "controlled metals" inspection processes. This revolutionary technique, together with the finest equipment for aluminum and zinc die casting, machining and every type of finishing, is proving of practical benefit to many of America's leading manufacturers.
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Tables to Guide in the Selection of Materials (continued)

SAND CAST ALUMINUM ALLOYS

MATERIALS AVAILABLE	APPLICATIONS	REMARKS
Alcoa #43	Used for non structural aircraft fittings; architectural and ornamental parts; pipe fittings, tank fittings and marine castings. For intricate castings having thin sections and parts which must be pressure tight. Suitable for permanent mold castings. Used also for die-castings.	Relatively low physical properties with excellent foundry characteristics. Good corrosion and shock resistance. Can be welded. Not heat-treatable.
Alcoa #195 Treatments T4, T6 and T62 (Ref. Alcoa #356)	Engine crank cases, outboard motor parts, machine bases; shop crane, and trolley parts, and aircraft landing wheels. For parts requiring good strength, corrosion and shock resistance. For permanent mold castings specify #B-195.	Heat-treatable. Moderate strength and ductility. Do not weld. For intricate, thin walled castings where lower shock resistance is permissible, substitute Alcoa #356. #356 has superior corrosion resistant qualities, is non-porous (suitable for use in pressure applications) and has slightly lower physical properties.
Alcoa # 220 Temper T4	Heavy duty castings, power shovel dipper parts, truck and railway car parts. For high strength structural aircraft fittings. Generally used only where high stresses are encountered.	Heat-treatable. Highest combination of physical properties of all aluminum alloy castings. Unsuitable for applications requiring pressure tightness or which are subjected to elevated temperatures. Requires special foundry techniques. Difficult to cast intricate shapes and to obtain sound castings. Do not weld. Fair corrosion resistance. Good machinability.

SAND CAST COPPER ALLOYS

Leaded Red Brass (Ounce metal)	For hydraulic castings such as pump bodies, low pressure valves and fittings. For intricate castings and for castings having thin sections.	Moderate strength, close grained. Good casting properties and machinability. Rich color. Low cost. Do not use at temperatures exceeding 400 deg. F. Unsuitable for bearings.
Manganese Bronze	For high pressure hydraulic valves and marine propellers, parts requiring strength and toughness. High strength types suitable for gears, slow worm drives, lead screw nuts and heavy-duty slow speed bearings subjected to severe shock such as turntable disks and bridge bearings.	Excellent corrosion and impact resistance. High strength. Can not be welded or brazed. High shrinkage. Do not use in high speed bearings. Wear resistant under slow moving loads. High tensile type manganese bronze has higher strength and hardness.
Leaded Tin Bronze (phosphor bronze—SAE 64)	Universal alloy for bearing and bushing applications at both low and high speeds and moderate pressures. Suitable for bearings subject to shock and vibration with inadequate lubrication. Use whenever resistance to wear due to friction must be minimized.	Non-seizing, non-scoring with low coefficient of friction. Good machinability (approx. 95 percent free-cutting brass). Poor weldability. For heavy duty, slow moving loads use stronger varieties of manganese bronze.
Aluminum Bronze (Available in Grades A & B)	For parts subjected to severe corrosion and elevated temperatures. For engine valve guides, anti-aircraft searchlight parts, furnace castings and mill slipper bearings. Grade A is applicable to spur, helical and bevel gears mated with hardened steel gears.	High strength. Good wear and repeated shock resistance. Hard. Maintains physical properties and resists scaling at high temperatures. Poor foundry characteristics and machinability. Grade B is generally heat-treated. Under certain conditions is suitable for bearing or worm gear use.
Beryllium Copper	For heavy duty brake and clutch drums, high strength aircraft fittings and brackets such as gun mounts, safety tools, resistance welding electrodes, circuit breaker parts, pump impellers and marine propellers.	High "as-cast" physical properties with good ductility. Heat-treatable. Very high impact resistance with high proportional limit. Good corrosion resistance. Good castability and machinability. Good electrical properties.

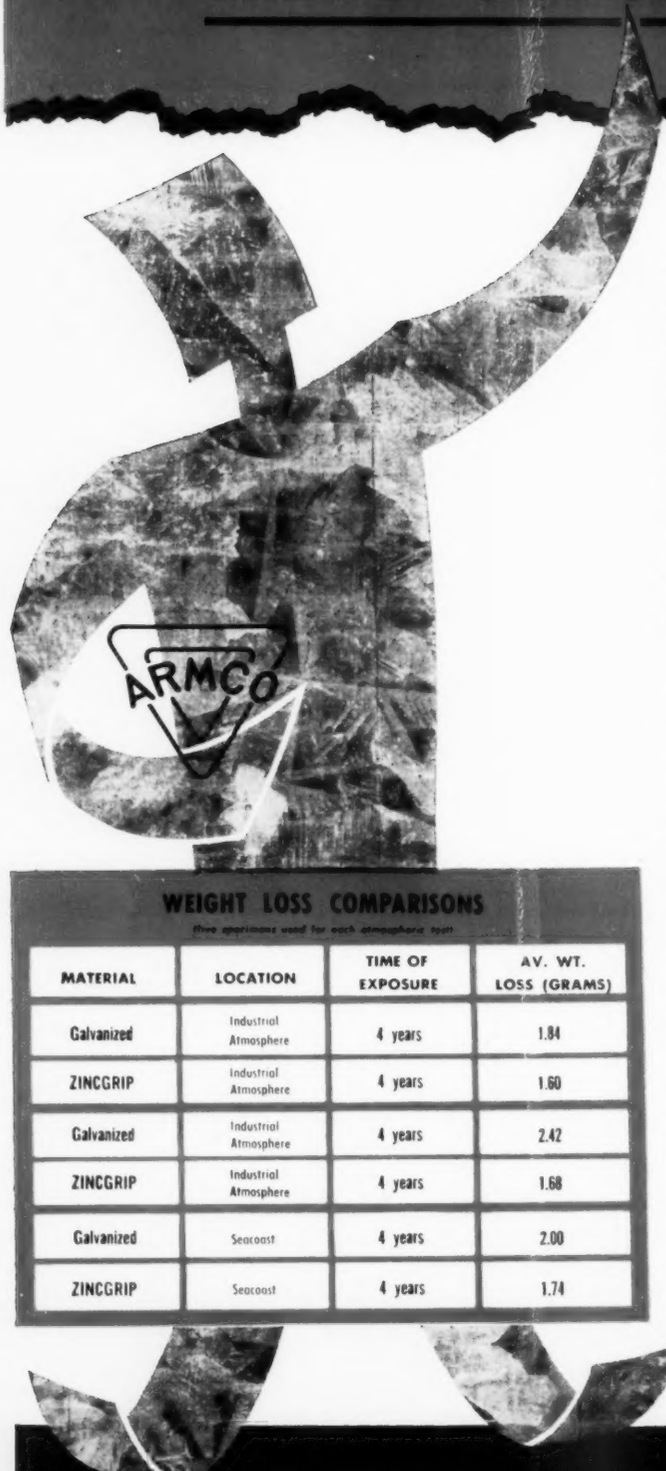
SAND CAST MAGNESIUM ALLOYS

AM 260 Treatments T4, T6 Dow C	When heat-treated, is used for moderately stressed structural castings of intricate design and where light weight is first requirement. Aircraft engine accessory cases and landing wheels. Suitable for permanent mold castings.	Requires careful heat-treatment. Good foundry characteristics. Poor abrasion resistance. Do not use at elevated temperatures. Suitable for pressure tight castings. Do not arc or gas weld. Highest strength in T6 (heat-treated) condition. Excellent machinability. Good corrosion resistance.
AM 265 Dow H	For moderately stressed, lightweight structural parts requiring good shock resistance, and complicated parts which may have a tendency to warp during heat-treatment. Aircraft structural supports, brackets, engine castings and portable tool housings.	Highest strength when not heat-treated. Do not use if pressure tightness is required as it is subject to porosity. Poor abrasion resistance. Do not use at elevated temperatures. Do not arc or gas weld. Good corrosion resistance. Excellent machinability.

DIE-CASTING ALLOYS

Aluminum Alloy SAE 304, 305, 307 Alcoa #43, 13, 85	Aluminum die-casting materials have good casting characteristics. Impact strength is inferior to zinc alloys. Aluminum alloys can be used at higher temperatures than zinc alloys. Used in household equipment, auto parts and housings, junction boxes and covers.	General purpose material. For parts where strength is unimportant use #304 and #305. #305 has high corrosion resistance and is suitable for large and intricate castings. #307 has slightly better physical properties. Alcoa #218 is used where higher strength, corrosion resistance, and ductility is desired.
Magnesium Alloy SAE #501 AM 263, Dow R	Aircraft engine openings, covers, housings, brackets and instrument parts; electrical conduit fittings, fans and textile machinery parts.	Used where light weight is a prime requirement. Excellent machinability. For intricate castings substitute AM 230.
Yellow Brass, Silicon Brass	The brasses have the highest physical properties of all the commonly die-cast materials. They have the worst casting characteristics. Die cost is high due to high melting point. Material cost is generally high. Applied where weight is not a factor and where strength and rigidity is of first importance.	Yellow brass is relatively cheap, has good strength and ductility. For better castability, higher strength, but lower ductility use Silicon brass. Yellow brass has best machinability.
SAE #921, 903, 925 ASTM XXI, XXIII, XXV New Jersey Zinc Co. #2, 3 and 5	Zinc base die-casting materials generally have best castability. Physical properties are inferior to brass but superior to most other alloys. Low die cost. Not recommended for use in contact with steam or water unless properly protected. Housings for small machines; handles gears, cams, carburetor parts and locks.	#921 has highest hardness. #903 has best dimensional stability and retains impact strength with age. #921 and #925 have best corrosion resistance. #925 has best combination of strength, impact resistance and dimensional stability.

This Special Zinc Coating Offers 15 to 45% GREATER CORROSION RESISTANCE



This range of 15 to 45% greater atmospheric corrosion resistance than regular galvanized coatings is the record of ARMCO ZINCGRIP in *actual field tests.*

When Armco Research engineers perfected ZINCGRIP in 1936, they knew this revolutionary zinc-coated steel would take severe forming and drawing without peeling or flaking of the special zinc coating. And accelerated laboratory tests indicated ZINCGRIP had another important advantage—much greater corrosion resistance than regular galvanized steel.

But in line with Armco's established testing policies these engineers put ZINCGRIP on the toughest proving grounds for metals—years of *actual field tests.* Only in this way could they be *sure* of ZINCGRIP'S superior corrosion resistance.

EXPOSURE TESTS

Exposure tests were made in various corrosion yards in different kinds of atmosphere.

ARMCO ZINCGRIP coatings averaged much less weight loss than the regular galvanized coatings among samples exposed for four years to both mild industrial and seacoast atmospheres. (See Table.)

After six years in a mild industrial atmosphere yellow rust appeared on *all* the regular galvanized specimens with a 1-ounce coating, but there was no indication of rust on *any* ZINCGRIP samples, including those with a 1-ounce coating.

Tests made by The American Zinc Institute with stock-watering tanks also show that ARMCO ZINCGRIP has *marked superiority* over regular galvanized in underwater exposure.

★ ★ ★ ★ ★

ZINCGRIP is only one of Armco's Special-Purpose Steels. Others include Stainless Steel sheets, strip, plates, bars and wire, and ALUMINIZED Steel (the only sheet steel with an aluminum coating). The American Rolling Mill Company, 402 Curtis Street, Middletown, Ohio.

WEIGHT LOSS COMPARISONS

three specimens used for each atmospheric test

MATERIAL	LOCATION	TIME OF EXPOSURE	AV. WT. LOSS (GRAMS)
Galvanized	Industrial Atmosphere	4 years	1.84
ZINCGRIP	Industrial Atmosphere	4 years	1.60
Galvanized	Industrial Atmosphere	4 years	2.42
ZINCGRIP	Industrial Atmosphere	4 years	1.68
Galvanized	Seacoast	4 years	2.00
ZINCGRIP	Seacoast	4 years	1.74

Help keep steel flowing from the mills by turning in your scrap promptly. The need is critical—the shortage *greater* than during the war.

THE AMERICAN ROLLING MILL COMPANY **ARMCO ZINCGRIP**

NEW MATERIALS AND PARTS

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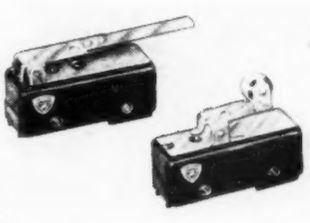
Hinged-Arm Actuators

Unimax Switch Corp., 460 W. 34th St., New York 1, N. Y.

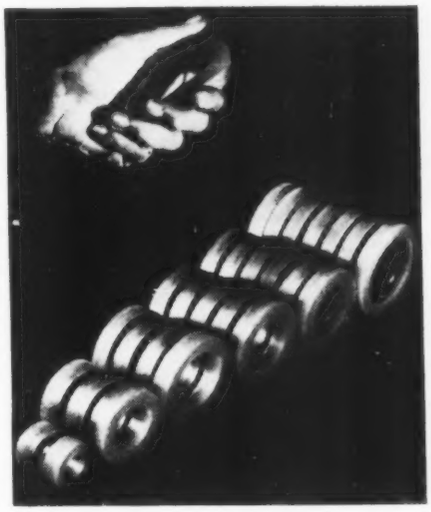
Direct-acting and reverse-acting hinged-arm auxiliary actuators for Unimax precision switches are available with a wide range of shapes and sizes. The direct-acting hinged-arm Adaptaplate is designed to meet requirements for very low operating force. The reverse-acting type provides long over-travel with flat force gradiant independent of switch characteristics; this unit permits full over-travel with no over-pressure on the basic switch. Since hinged-arm Adaptaplates require special length operating buttons, they are not interchangeable with the primary type.



Compar Rollers

Resistoflex Corp., Belleville, N. J.

A material used in many low and medium pressure fuel, lubricating and hydraulic systems, compar is now being used on bag and envelope machinery. Feed, friction and guide rollers for these machines are being manufactured of compar because of its long life span discovered under test. It is said that the use of compar has reduced maintenance costs and machine down time. Compar does not wear as rapidly as leather, and

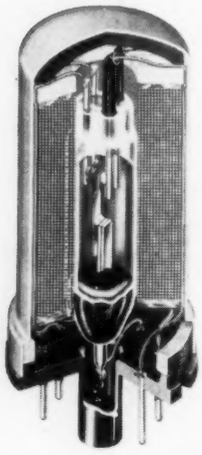


natural or synthetic rubber, and has inherent non-static properties. This material is unaffected by all fuels, oils and other organic solvents. It is light in weight, with high tensile strength, is non smearing, and has high resistance to wear and abrasion.

High Speed Relays

Western Electric Co., 195 Broadway, New York 7, N. Y.

These mercury contact relays have been developed for application to all types of high speed switching devices where accurate time characteristics are desired. They have long service life, high operating speed, large current and voltage handling capacities, and uniform and constant operating characteristics under any adverse atmospheric condition. As the contacts and magnetic motor elements are hermetically sealed in a hydrogen filled glass envelope, they are free from the effects of moisture, dirt and corrosion. The use of mercury-wetted contact surfaces gives almost instantaneous break of contacts. Mercury wetting on the fixed and moving contacting surfaces is maintained by a capillary wick-feed system. The 275 type relay is comprised of a single switch element and operating coil and is of the neutral form; with the operating coil non-energized, the armature is normally closed on the back contacts of the switch. The 276 type relay is

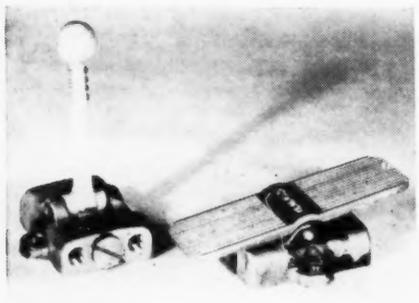


similar except for the inclusion of a permanent magnet bias and a correspondingly slight increase in height. The addition of the magnetic bias permits the 276 to be factory adjusted to operate at specific current levels. These adjustments can be made to give biased or polarized operating characteristics. Because of the presence of mercury in the switch elements, the minimum ambient temperature is —37.8 deg Fahrenheit. The maximum internal temperature must not exceed 170 deg Fahrenheit. The life expectancy of these units is claimed to be 10^9 operations when operated within their ratings. The repetitive precision with which a given relay may be expected to operate is within one percent of its minimum operating current. They are housed in metal envelopes with standard octal bases and give optimim performance when operated in a vertical position.

Air Control Valve

Ross Operating Valve Co., Dept. k, 6495 Epworth Blvd., Detroit 10, Mich.

This control is a small poppet-type valve designed expressly for operation of light machine tools, vises, fixtures, presses and other machinery adaptable to air control. The valve is constructed of brass and stainless steel, with a hi-carb neoprene valve seat. Hand lever or foot

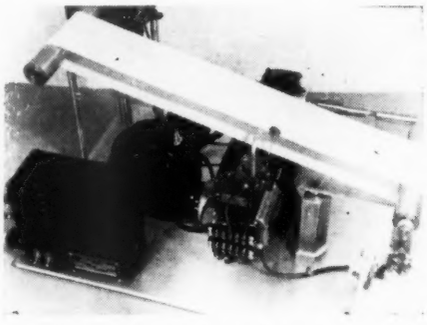


treadle operation is optional and adds to the versatility of the control unit. The vertical lever action is particularly suitable for small machine tool installations. In the foot treadle style, No. 600 is 3-way, No. 601 is 4-way. The hand lever type No. 602 is 3-way, No. 603 is 4-way. All are available in locking, non-locking or neutral position types.

Power Control

W. C. Robinette Co., South Pasadena, Calif.

A pacakaged continuous-balance control system of great sensitivity, the Motron Servo 61A can be used to control or regulate a variety of processes without the necessity of human supervision. Several miniature vacuum tubes directly control, without circuit-breaking contactors, the speed and direction of a standard 1/15 hp induction motor ac-



cording to the setting of the input dial. The motor can be used to control larger power sources. The input dial is mounted on selected precision ball bearings and can be rotated by extremely small forces such as electric meter movements, pressure and flow gages, nylon or silk filaments, synchronous electric clocks, wet paper fibers and magnetic compass needles. The velocity of position of the motor can be limited from zero to maximum independently of the input dial setting so that hunting instability cannot occur. The motor can actuate a process-changing device and alternately may act as a torque amplifier or as a remote position agent. Since the motor velocity and not the torque is controlled, load change or complete loss of load cannot cause instability.

Unthreaded Fastener

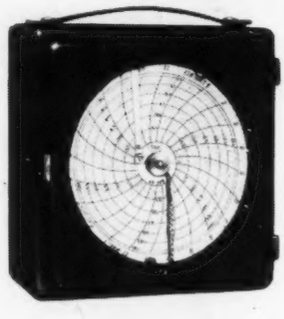
Tinnerman Products Inc., 2041 Fulton Rd., Cleveland 13, Ohio.

These Speed Clips can be used on many installations where blind fastening is necessary. They have been used for installing oven thermostats after the oven has been assembled. Access to the reverse side of the panel was impossible when the thermostats were installed. Since the spring arms can be made in many shapes, these clips can be used for holding many types of auxiliary equipment. To install, the long shear leg of the clip is inserted into a 5/16 in. hole with forward finger pressure. When the rear leg snaps into position, the clip cannot back out.

Temperature Recorder

C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn 5, N. Y.

Designed for use in the many applications where a shock resistant, easily portable temperature recording instrument is necessary, this recorder is suitable for use in trucks, railroad cars and airplanes in transit. Because of its miniature size and portability, it is also useful for checking refrigerating, heating and air conditioning equipment. The instrument is available in two forms; the single pen recording thermometer for recording temperature only, and the two pen temperature and time operation recorder, which charts the running time of refrigeration motors in addition to recording temperature. A special transparent, unbreakable plastic front permits full view of entire chart



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When the application calls for sudden shock or impact . . . Johnson Sleeve Bearings are the first choice. The large, unbroken bearing area distributes the jolts over a greater surface . . . eliminates the danger of distortion . . . provides easy, economical operation for a greater period of time.

When you need sleeve bearings to carry the heavy loads, to withstand shock and impact, call on Johnson Bronze. We have the experience, the equipment, and the skill to meet every requirement. And we can give immediate service.

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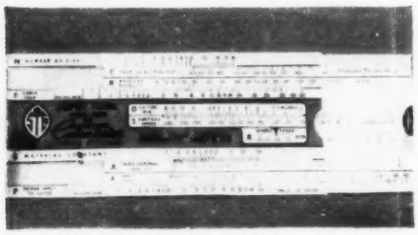
- HIGH RESISTANCE TO SHOCK
- LOW COEFFICIENT OF FRICTION
- EASY TO INSTALL
- CONFORMABILITY
- NATION WIDE SERVICE

and pen arm. The instrument is available in models to operate in a wide variety of ranges. Chart drive is a 7 day spring propelled mechanism with charts of 24 or 72 hour duration. Each recorder is inclosed in an aluminum case, 5¾ in. square by 4¼ in. deep, giving a total weight of less than 3½ pounds.

Carbide Calculator

Super Tool Co., Box 68 Harper Station, Detroit, Mich.

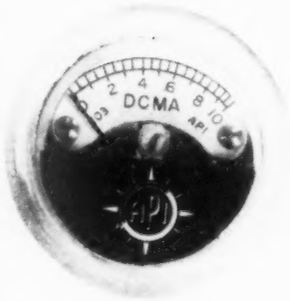
This pocket calculator is used for computing speed, feed and horsepower necessary for carbide milling operations. The proper cutter to be used for various hardnesses and types of steel, as well as non ferrous metals, can be determined with this plastic calculator which works on the slide rule principle. Speeds, feeds, etc. for carbide milling that only experienced carbide men have been able to determine can now be computed with reliable accuracy by inexperienced job setters. The calculator scales are based on Super Tool Company's experience over a period of years in all types of carbide applications, and only a few minutes are required to arrive at tooth load, table feed, spindle speed and the horsepower required to perform the operation. Operating instructions are printed on the reverse side of the calculator.



Miniature Meters

Assembly Products Inc., Chagrin Falls, Ohio

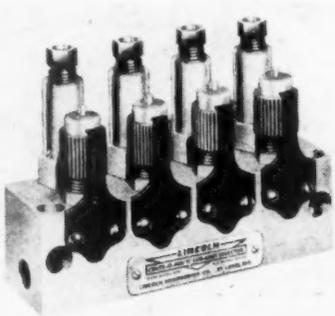
Believed to be the smallest, high grade, D'Arsonval type meter commercially available, this Super Midget Meter has a 1 in. diameter. The depth behind the front of the mounting panel, including terminal studs, is 1 inch. Maximum overall dimensions, including studs and mounting flange, are 1 3/16 x 1 3/16 inches. The movement, mounted on polished pivots in Vee jewels, has small mass and low inertia that will stand rough usage. Many have withstood a free drop in excess of 24 in. on a wood block without damage to the case or movement. Alnico V magnets with machined soft iron poles provide high flux to give movements with low response time and good damping. Moving elements are accurately poised with movable balance weights. Lucite, polystyrene, lumarith and other clear plastic cases are available, and hermetic sealing is possible when needed. Voltmeters, milliammeters, ammeters, millivoltmeters and microammeters can be supplied. The maximum voltage range, self-contained, is 500 volts. Rectifier type a-c as well as thermocouple instruments are available.



Lubricant Injector

Lincoln Engineering Co., 5701 Natural Bridge Ave., St. Louis 20, Mo.

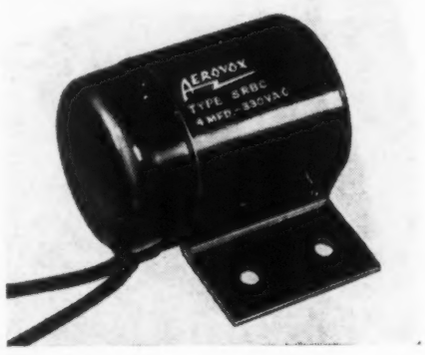
The Type SL-3 Lubricant Injectors are small, compact, space saving units especially designed for use where mounting space is limited. These injectors have only two moving parts, the valve stem and piston, which operate in packings of oil- and grease-resisting Linpak material. This type of packing compensates for normal wear that would otherwise result in leakage between metal to metal seals. The Type SI-3 Injectors are available singly or in manifolds of two, three or four. Base blocks are drilled so that these units can be mounted either vertically or in horizontal position on machines. Injectors can be individually set so that the exact amount of lubricant required is delivered to each bearing. Discharge of injectors is by positive displacement for maximum accuracy. The knurled adjusting knob can be turned to a desired setting by hand, and a spring clip-lock prevents any change that might result from machine vibration. Each injector block has a ⅛ in. I.P.T. female connection at each end. Outlet of each injector is ⅛ in. OD tube. Injectors are adjustable to maximum lubricant output of 0.004 ounces per cycle.



Motor Capacitors

Aerovox Corp., New Bedford, Mass.

Fully protected against mechanical damage, dirt and the usual climatic conditions, these bracket-mounted, armored capacitors are distinguished by their small size. The flexible pigtail leads from the incased capacitor are brought out through an insulated hole in the cap. The unit can be mounted by two screws. The steel case is 2 1/16 in. in diameter by 2⅞ to 3¾ in. long, depending on voltage and capacitance ratings. Standard ratings range from 1 to 8.5 mfd for 110, 220, 330, 440 and 660 v. a-c service.



Solenoid Water Valve

Weltronic Co., Dept. K, 19498 W. Eight Mile Road, Detroit 13, Mich.

Relieving the operator of the duty of turning on or shutting off the cooling water in a welding operation, the Water Saver can be used with any type of welding machine. This unit is designed so that its two control relays and the solenoid operated water valve are de-energized if the welding machine is stopped for a period of time longer than 30, 60, or 90 seconds; the three time ranges available. De-energizing the water valve stops the flow of cooling water; starting the welding machine energizes the Water Saver's initiating transformer, which is connected to the air solenoid valve coil on the welding machine. Installation of the Water Saver reduces condensation, avoiding transformer shorts; cuts water use dur-

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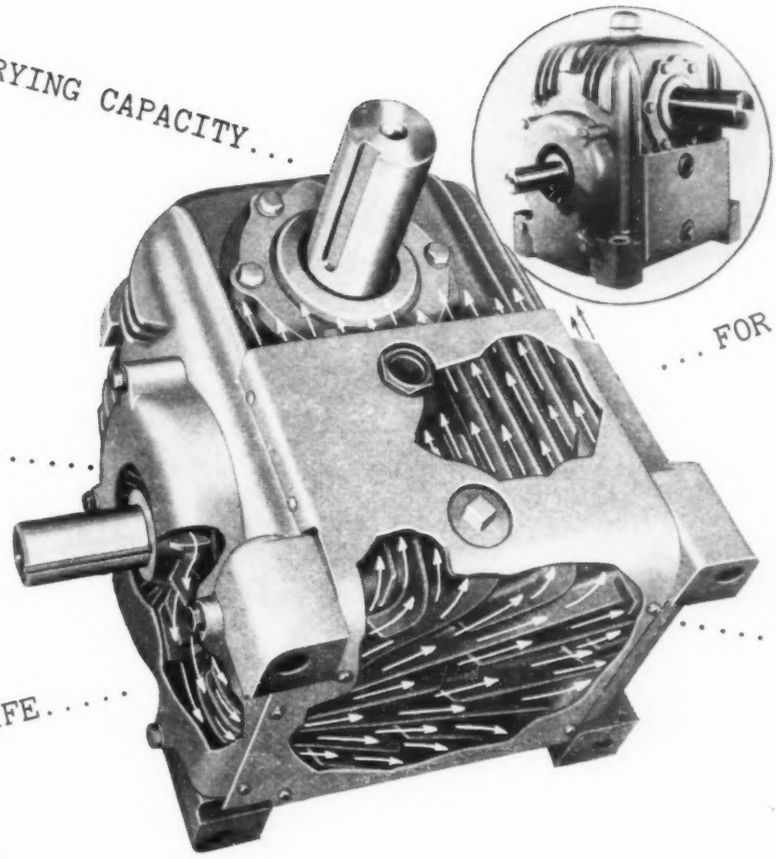

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IDENTICAL THERMAL AND MECHANICAL RATINGS
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In these new fan-cooled reducers you have the ideal unit for installations where thermal capacity is the limiting factor on load carrying capacity, just as non-fan-cooled Cone-Drives are "tops" where you need mechanical load capacity primarily.

What is more, you do not have to pay for a "special" reducer. Cone-Drive standard pinion-under models 7400 to 7800 inclusive are designed for use either with or without fan-cooling. This standardization and manufacturing economies mean lower cost to the user and simple convertibility.

For complete information, write, wire or call:

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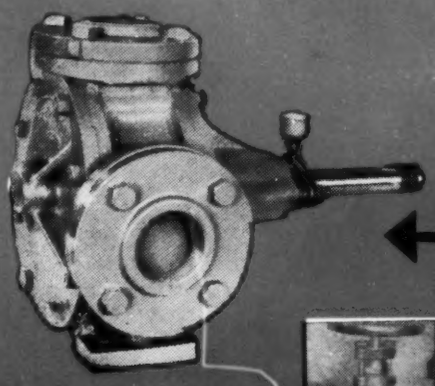
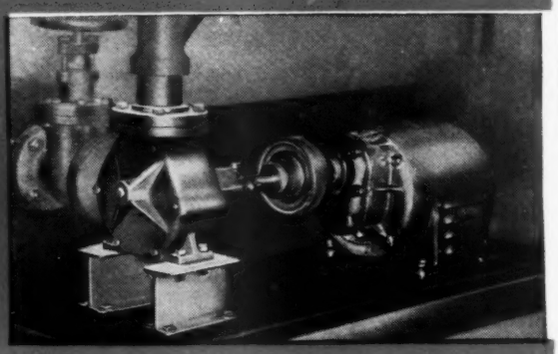


AND THIS IS THE PUMP



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Positive handling characteristics and high volumetric efficiency are combined in one pump by means of the unique design of Yale & Towne's TRI-ROTOR rotary piston positive displacement pump.

It handles a wide variety of liquids — from volatile to viscous — without over-heating, chewing, foaming or agitating the product.

Only 3 moving parts (two pumping members) — minimum operating and maintenance expense.

Optional and interchangeable: Variable Volume Control (with or without Manual Flow Control), Integral Relief or By-pass valve, Solid Head.

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Pressure Regulator Device permits operator to adjust hydraulic mechanism to control *both* volumetric capacity and discharge pressure without stopping the unit.

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☐ Corn Syrup	☐ Ink	☐ Paint	☐ Varnish
☐ Edible Oils	☐ Honey	☐ Propane	☐ Viscose

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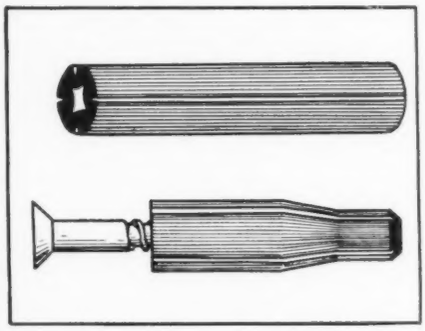
ing idle time, lowering water costs; eases overloaded disposal systems, with a saving to pumps; decreases mineral deposits, repair and down time; and reduces sweating, rust and corrosion. The Water Saver is inclosed in a heavy sheet metal cabinet, with all components mounted on a control panel easily removed for inspection. Two type 2D21 Thyratron tubes and two relays are employed in the control circuit. Power supply can be 115, 280 or 460 v, 60 cycle, single phase current.

Screw Anchors

Holub Industries, Inc., Sycamore, Ill.

Sandscott Plastic Expanding Anchors are used to hold wood or lag screws in any kind of rigid material. Overlapping internal and external slits give a "concertina" effect that insures high holding power. While testing these anchors, some of the screws broke without being pulled from the anchors or holes. The maximum load pull was 2,965 lb using a No. 20 screw. The anchors are made slightly larger in diameter than the size of the hole to be

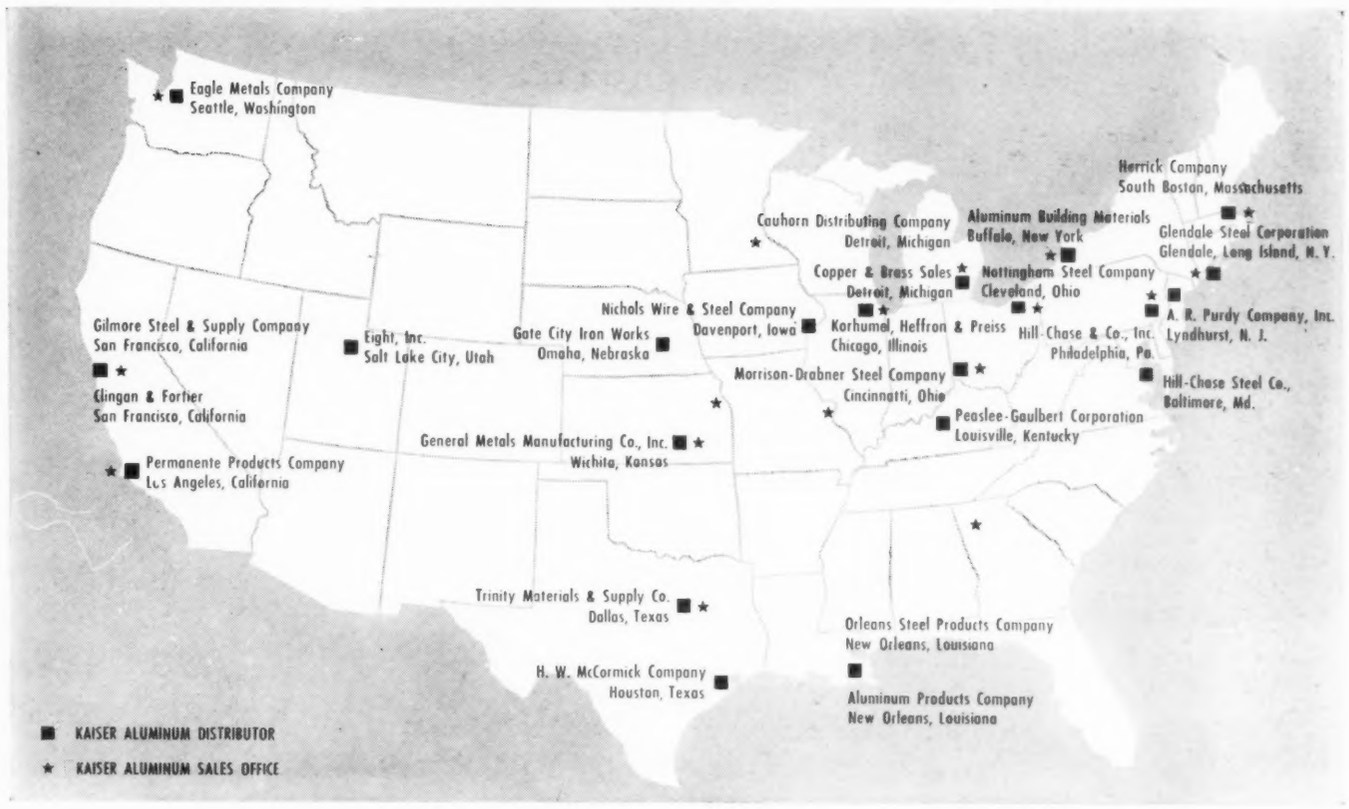


drilled. The anchor can be compressed and driven into the hole with a hand hammer. The plastic used in manufacturing these anchors is tough and pliable and has a tensile strength of 5,000 lb per sq inch. It is uneffected by water, moisture, weather or acids, and can be used at temperatures from —78 to 180 deg Fahrenheit. These anchors are available in seven sizes of various lengths to accommodate screws from No. 5 to No. 20, or ¼ and 5/16 in. lag screws. The anchors can be cut to any length with cutting pliers, knife or saw.

Heat Transfer Plates

Platecoil Div., Kold-Hold Mfg. Co., Lansing, Mich.

With the aid of Platecoils, it is now possible to manufacture heated tanks with a completely flat interior surface and without any protruding coils. The Platecoil has a flat surface on one side and is embossed on the other to form channels for the circulation of the heating agent. This construction avoids the necessity for internal tubing, reduces



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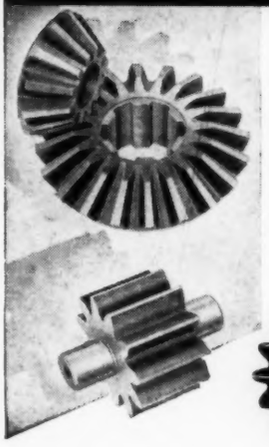

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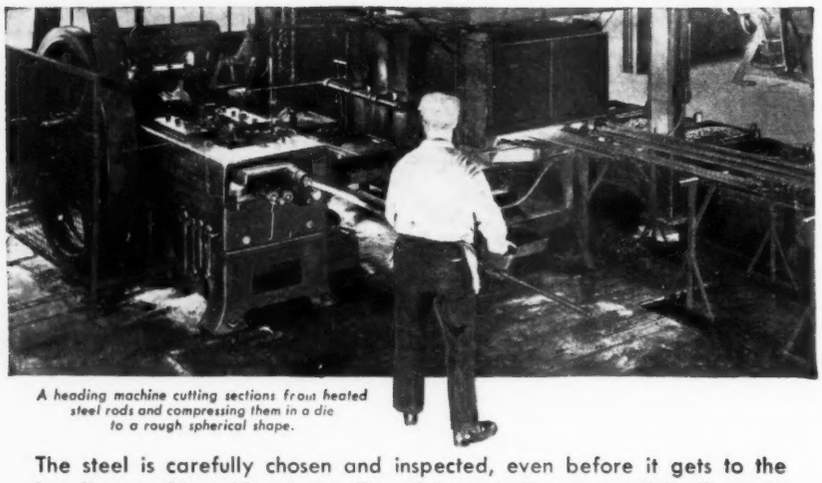
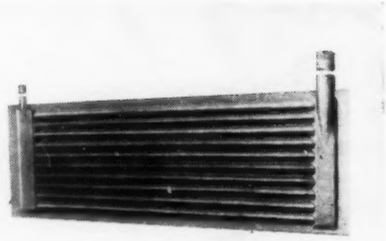


A heading machine cutting sections from heated steel rods and compressing them in a die to a rough spherical shape.

The steel is carefully chosen and inspected, even before it gets to the heading machine. After being "born" here, balls are carefully "brought up," through a long series of grinding and lapping operations, to the unbelievably high standards of finish, sphericity and precision which have made Strom Metal Balls the standard of Industry. Strom Steel Ball Co., 1850 South 54th Avenue, Cicero 50, Illinois.

Strom BALLS Serve Industry

Largest Independent and Exclusive Metal Ball Manufacturer

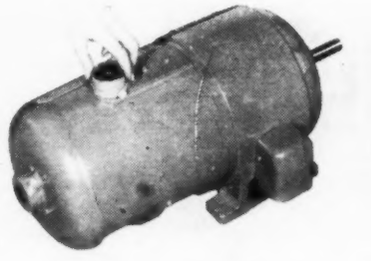


the weight per square foot and simplifies installation. It is claimed that these units require less space and will provide more productive capacity per given tank. It is possible to build the tank and install these plates in one operation. The flat surfaced plates can be formed and welded as part of the tank bottom, side walls or both. Platecoils can be furnished in steel with metalized surfaces of various metals, or in Monel, stainless steel or other specified metals. These are available as plates; in bank form; or fabricated into complete liners. Each plate is tested at 180 lb per sq inch.

Variable Speed Motors

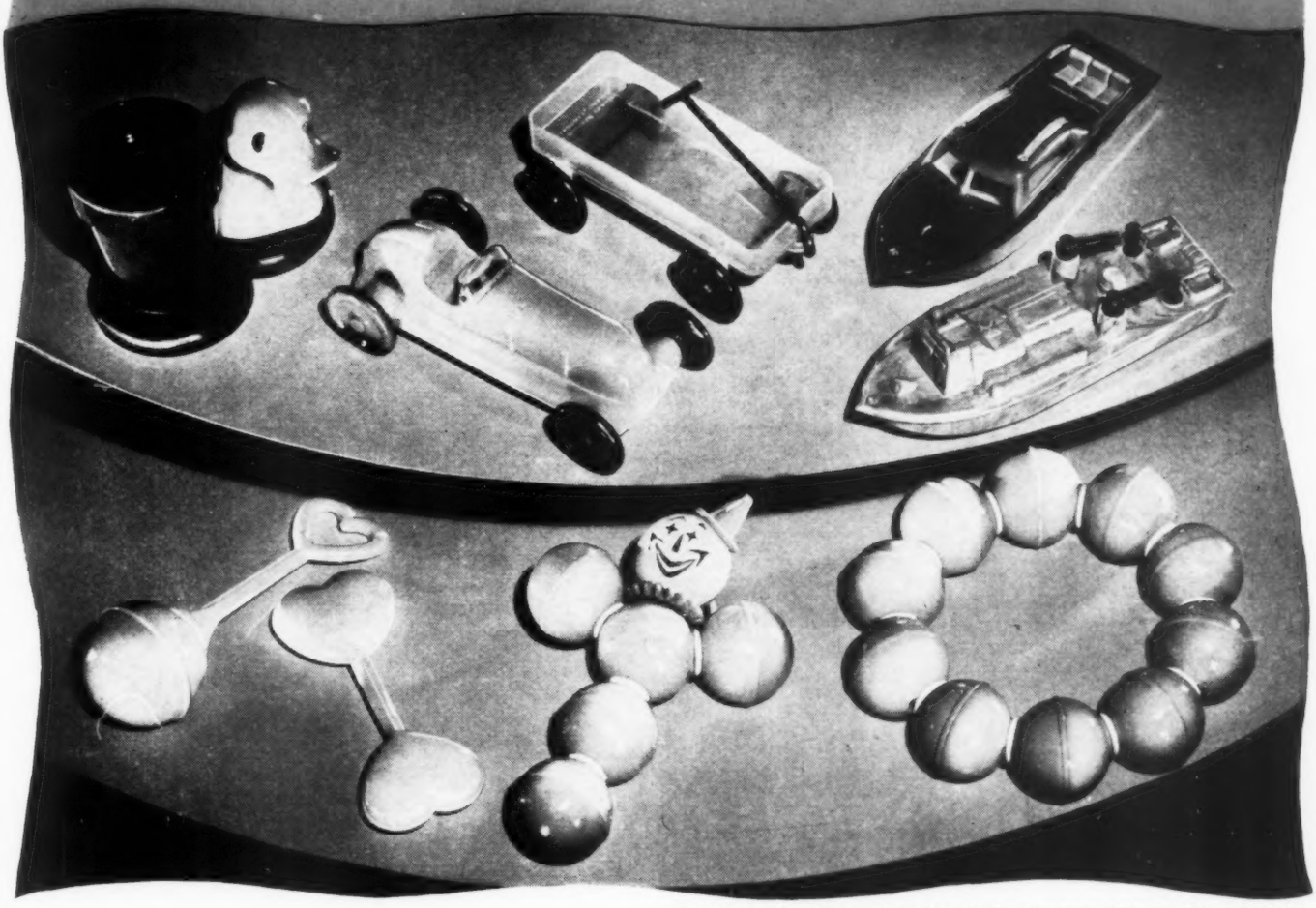
General Electric Co., Schenectady 5, N. Y.

Avaliable in ratings from 3 to 50 hp, 220, 440 and 550, v, the Tri-clad brush-shifting adjustable speed induction motor features stepless speed adjustment over a 3:1 ratio by simply turning a dial. The entire unit, with the exception of the starter control, is self contained in a housing only a little larger than that for a constant speed motor of comparable rating. Remote speed control can be accomplished by use of a flexible cable shaft up to 10 ft away from the motor. For complete remote control, a small pilot motor can



be used to drive the speed control mechanism. Uniform cooling with low intake velocity is provided by double end ventilation. Necessary over-load protection and limit switches to insure proper starting are built into the motor. The standard frames, 225 to 505, have NEMA mounting dimensions. Formex wire stator windings are used to give protection against oil and heat-aging. A cast iron bearing inclosure affords protection from moisture, dust and dirt. The motor will carry full load torque at rated current and frequency without

Acetate Toys *LAST* After Christmas!



Toys designed, molded, and marketed by Knickerbocker Mfg. Co., Glendale, Calif.

Toughness is important in children's playthings! Toys should not easily shatter—they should be durable enough to withstand the wear and tear of the Christmas season and provide many additional hours of enjoyment after the holiday excitement has passed. That is why millions of toys continue to be molded from cellulose acetate plastics—*the most economical plastic with this important durability factor!*

For Knickerbocker Mfg. Company, as for hundreds of other leading toy manufacturers, the choice of cellulose acetate brings many additional advantages in both fabrication and use.

Cellulose acetate is tougher than any thermoplastic of comparable price. It *gives* where some materials crack or shatter. As a result, interlocking sections of toys often are securely assembled merely by pressing together. Not being brittle, excess material can be removed after molding without damaging the part itself. Punching, drilling, and other finishing operations can be performed easily.

Economy is an outstanding feature of the cellulosics. Cellulose acetate's toughness enables manufacturers greatly to reduce breakage losses in fabrication and shipment. Cellulose acetate may be molded with much thinner walls than are practical with lower-cost thermoplastics. It flows freely and quickly into intricate molds, and often results in lower initial mold costs and faster molding cycles. Scrap can be processed and reused.

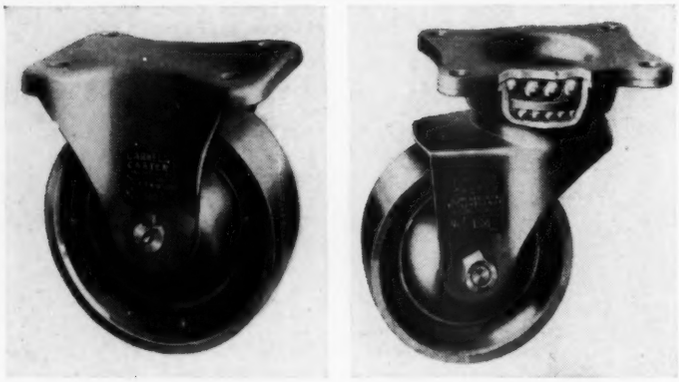
If you want your plastic toys to have the durability and colorability essential to *keep* customers sold, use *cellulose acetate* plastics! While Hercules does not make cellulosic plastics or molding powder, we will be glad to send you helpful technical literature on the Hercules base materials from which they are made.

HERCULES POWDER COMPANY
INCORPORATED
904 Market Street, Wilmington 99, Delaware

CP7-18

Save and Sell with Cellulosic Plastics

CELLULOSE ACETATE • ETHYL CELLULOSE • NITROCELLULOSE



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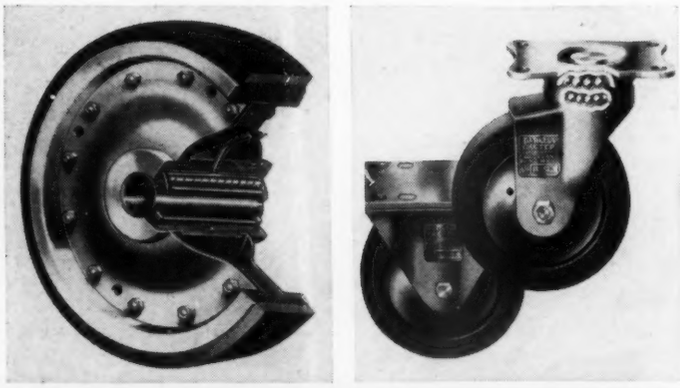
Casters & Wheels

If you want maximum floor protection, economy and efficiency Demand Darnell Dependability...Made to give an extra long life of satisfactory service .....



Free

MANUAL

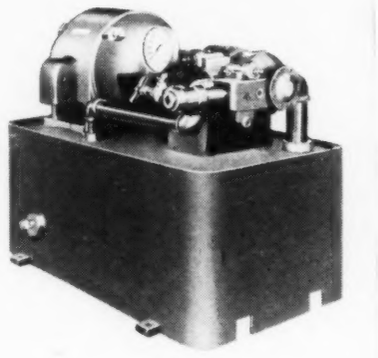
DARNELL CORP. LTD. 60 WALKER ST. NEW YORK 13 N.Y.
LONG BEACH 4 CALIFORNIA 36 N. CLINTON CHICAGO 6 ILL.

exceeding a temperature rise of 40 C on high speed or 50 C on low speed; measured by a thermometer on the windings. Power factor is high when the motor is running at high speed. At synchronous speed, it is about the same as with a squirrel cage induction motor of similar rating. For intermittent use, speeds below minimum rated can be obtained by adding secondary resistance. Plugging is possible by the same means. The motor is reversible for short periods of time by reversing two power leads. Inspection plates can be removed to inspect the brushes and brush-shifting mechanism.

Hydraulic Power Unit

Hannifin Corp., 1101 S. Kilbourn Ave., Chicago, Ill.

Equipment for these standardized hydraulic power units for use in conjunction with hydraulic cylinders and other hydraulically operated equipment includes pump, pressure relief and adjusting valve, flexible pump-motor coupling and hydraulic pressure gage. Standard motors are used. Distinguished outwardly by steamlined appearance and compact arrangement, the new units provide for any required pump capacities from 1 gpm up, and for pressures of 2,000 psi, or more.



Spring Shackles

Harris Products Co., 5105 Cowan Ave., Cleveland 4, Ohio.

Used as original equipment or as replacement parts, these shackles double and triple the life of spring shackle assemblies without material increase in cost. In the Concentrated Pressure shackle, the degree of angle through which it can turn without slipping and the load it can carry, are determined by the relationship of coefficient of friction, area of contact between rubber and metal, and by effective pressure applied to the rubber bushing. Since any increase in the area of contact would also

"This advertising message, appearing in 4-color cover position in NEWSWEEK, BUSINESS WEEK and U. S. NEWS, is developing business for Monsanto Lustron molders and fabricators."

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BORING BARS
Boring Bar Box—Molded by South Gate Tool Engineering Co., South Gate, California.
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You can use Lustron to *make products* . . . or to *make them sell,* too!

Today, many alert merchandising manufacturers put Lustron to selling via beautiful, appealing packages for their products . . . for premiums, for displays, for package components, and accessory or optional attachment kits.

You see here, three typical outstanding selling jobs by Lustron in the industrial field. Instead of tying a muslin bag full of accessories on to the order . . . or putting tools into a dull looking box . . . these smart manufacturers present them in cleverly designed, fitted boxes molded of Lustron.

The small extra costs of these attractive kits are more than paid for by the lasting satisfaction and impression of good value the buyer receives.

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If you would like to know more about how Lustron can serve you as a star salesman, address: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Massachusetts. In Canada, Monsanto (Canada) Limited, Montreal.

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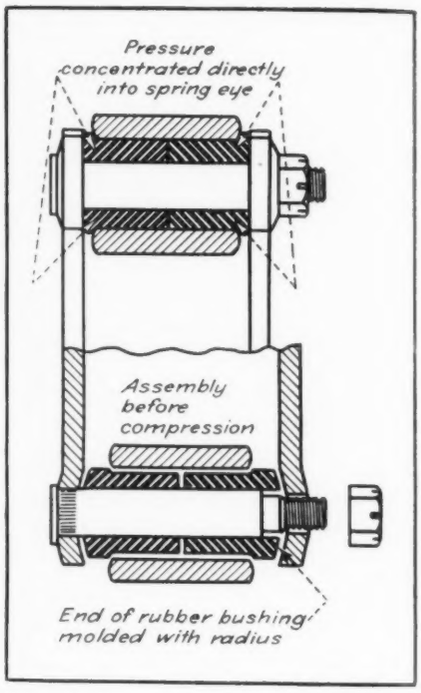
4 CYCLE
BRIGGS & STRATTON
GASOLINE ENGINES

For Top Performance and Long Life

The Briggs & Stratton trademark on each gasoline engine is assurance of *reliable power* for your equipment. This is proven by the 28-year performance record of more than 3¼ MILLION Briggs & Stratton engines. Only engines sound in design and ruggedly built could create the world-wide preference which Briggs & Stratton engines *have earned.*

Briggs & Stratton engines *have more experience built into them* than any other 4-cycle air-cooled engines.

BRIGGS & STRATTON CORP., MILWAUKEE 1, WIS., U.S.A.


Pressure concentrated directly into spring eye
Assembly before compression
End of rubber bushing molded with radius

mean increased size and cost, concentrated effort was placed on a means for effectively increasing pressure without increasing cost. This has been done by molding the rubber bushing with a radius rather than a straight line shoulder, with correspondingly redesigned side plates for effectively concentrating the compressive force directly into the spring eye. This concentrated pressure feature not only greatly increases the life of the spring shackle on passenger cars, but with the higher unit loading made possible by increased pressure within the spring eye, makes it applicable to commercial vehicles without the prohibitive number of eye sizes previously necessary.

Control Unit

Kollsman Inst. Div., Square D Co., 80–08 45th Ave., Elmhurst, N. Y.

An unusually sensitive mechanism, the Synchrotel serves as a virtually frictionless voltage control and synchronous transmitter. Although developed primarily for use in aircraft instrumentation, this control will have a wide application in various process industries. This electro mechanical control device is in essence an a-c synchromotor, or an electromagnetic pickoff device. The Synchrotel can be attached directly to the pointer of the most sensitive aircraft and other instrument without affecting the accuracy of the instrument. It will convert its reading into electrical signals that can be sent to a remote station with accuracies of a fraction of a degree of arc. The signals can be used in a servomechanism to direct an airplane, control the engine temperature, operate a flight recorder or make the airspeed adjustment in a bombsight. In like manner, it can serve both in trans-

Stronger, Lighter Hand Truck Made by Welding Tubular High Carbon Steel

BY JAMES B. HOWLAND, PARTNER
TUBAR BENDING & MANUFACTURING CO., CLEVELAND, OHIO

THE new Tubar Hand Truck has outstanding strength and low weight because it is made of tubular high carbon steel with an exceptionally thin wall (.076″). Frame of the largest model Tubar weighs only 36 pounds, yet carries a 1,000-lb. load. Fig. 1 shows how light it is. The addition of reinforcing tubes from the kick-bar to the handle (see Fig. 3) makes a "stevedore" model with a 2,500-lb. capacity. Conventional hand trucks of these capacities weigh more than twice as much.

The all-welded tubular frame has other advantages in addition to lightness. Constructed without bolts or rivets, it has a smooth top and bed without obstructions. There is no danger from wood splinters or sharp edges of metal. Design of the frame distributes the load and reduces dead weight on the axle, facilitating handling. The operator's hands follow the curve of the handle in "breaking" the load to a pulling or pushing position. The Tubar Truck is patented.

JIGS USED IN WELDING

We use two sizes of tubing—1 1/16″ O.D. and 7/8″ O.D. The smaller telescopes into the larger size at the maximum stress point, for greater strength. The tubes are bent on a bending machine (see Fig. 2). The toe plates are bevelled and forged to a point. Toe-plate sides are cut from 3/4″ high carbon steel plate by an acetylene cutting machine. The frame parts are assembled in a jig and tack-welded, then finish-welded in another jig (see Fig. 3).

Fig. 1. Demonstrating the lightness of the Tubar truck.

In setting up production, we had difficulty welding the high carbon tubing until we tried the new Lincoln "Shield-Arc LH-70" electrode, designed for high carbon and other difficult-to-weld steels. With "Shield-Arc LH-70" we are able to weld speedily without costly preheating or special welding procedures.

Engineers and designers may obtain Studies in Machine Design by writing THE LINCOLN ELECTRIC COMPANY, **Dept. 369,** Cleveland 1, Ohio.

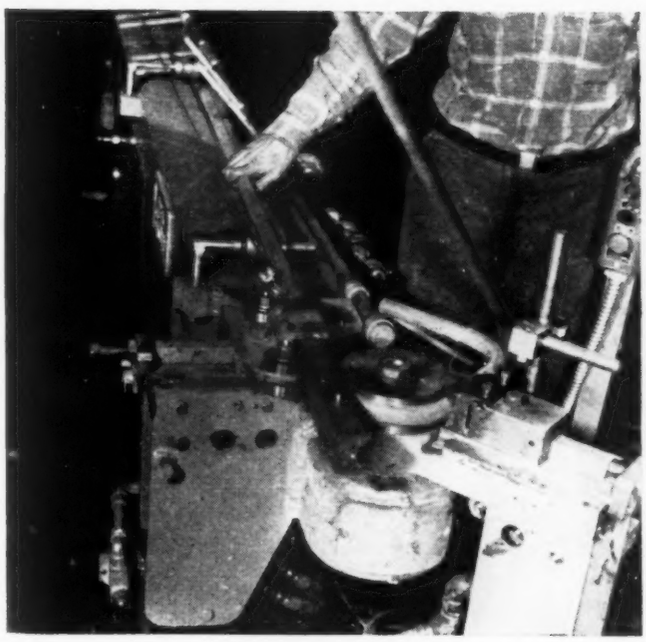


Fig. 2. All bending is performed on a tube bending machine.

Fig. 3. Finish-welding a "stevedore" model. Jig rotates so most welding is in downhand position.

Advertisement

SAVE SUPERVISION
in fitting
PRECISION PARTS

YOU PROBABLY KNOW Laminum shims as assembly time savers. But have you overlooked the fact that in fitting machine parts by peeling these precision laminations, considerably less supervision is required. You have the certainty of uniform accuracy . . . with no spoilage. Your request for data invited.

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Laminated Shim Company, Incorporated

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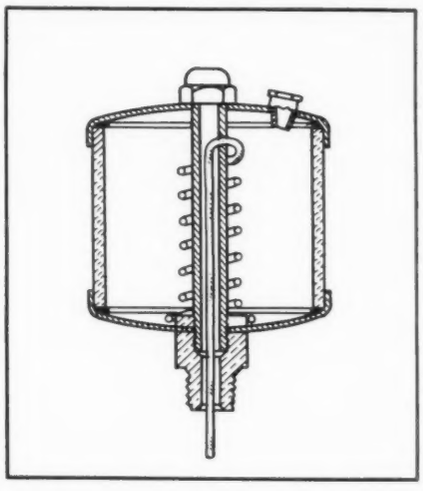
mitting and regulating steam pressure, temperature, flow of liquid, etc. in industry. The unique feature of this synchro is that the only moving part weighs but 1/25th of an ounce and can be mounted on tiny jeweled bearings. Thus it can be positioned by the torque produced by the pointer of precision instruments. The low weight and the consequent low inertia of the Synchrotel rotor enhance its usefulness where high angular accelerations and oscillations are to be measured or controlled.

Wick Feed Oilers

Oil Rite Corp., 3482 S. 13th St., Milwaukee 7, Wisc.

Oil in the reservoir of this feeder is carried through the wick over the standpipe to the bearing by capillary action assisted by a syphon effect. Oil of light or medium body can be used. Dirt or sediment cannot travel through the wick and reach the bearings, thus effectively filtering the oil. In order to obtain a regular and reliable feed, the variation in oil level should not be too



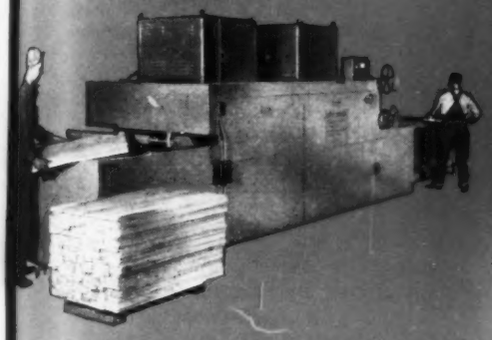
great. For this reason, large diameter reservoirs with shallow height have been designed. The brass body carries the Lucite reservoir between cork gaskets. The unbreakable Lucite reservoir is especially useful for those applications where the hazard of broken glass must be entirely eliminated. For applications where the temperature exceeds 150 F. glass should be used. These lubricators are available in five sizes with capacities ranging from ½ to 8 oz, and with suitable commercial pipe threads.

Curve Drawing Instrument

Cook Specialty Co., Green Lane, Pa.

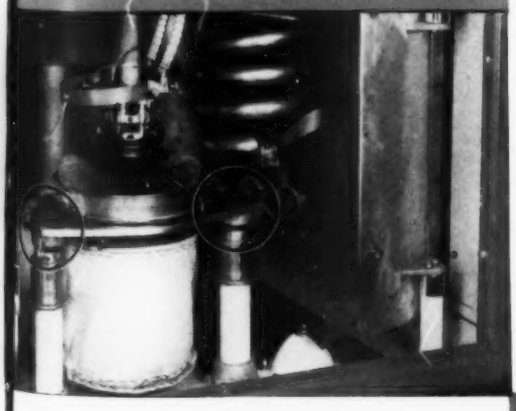
Used instead of fixed curves, the Infinarc is designed on a different principle. The desired curve is obtained with tempered wire forms, the shapes of which are altered by moving either or both of two adjustment screws along slots. The instrument has a 12 in. base and four

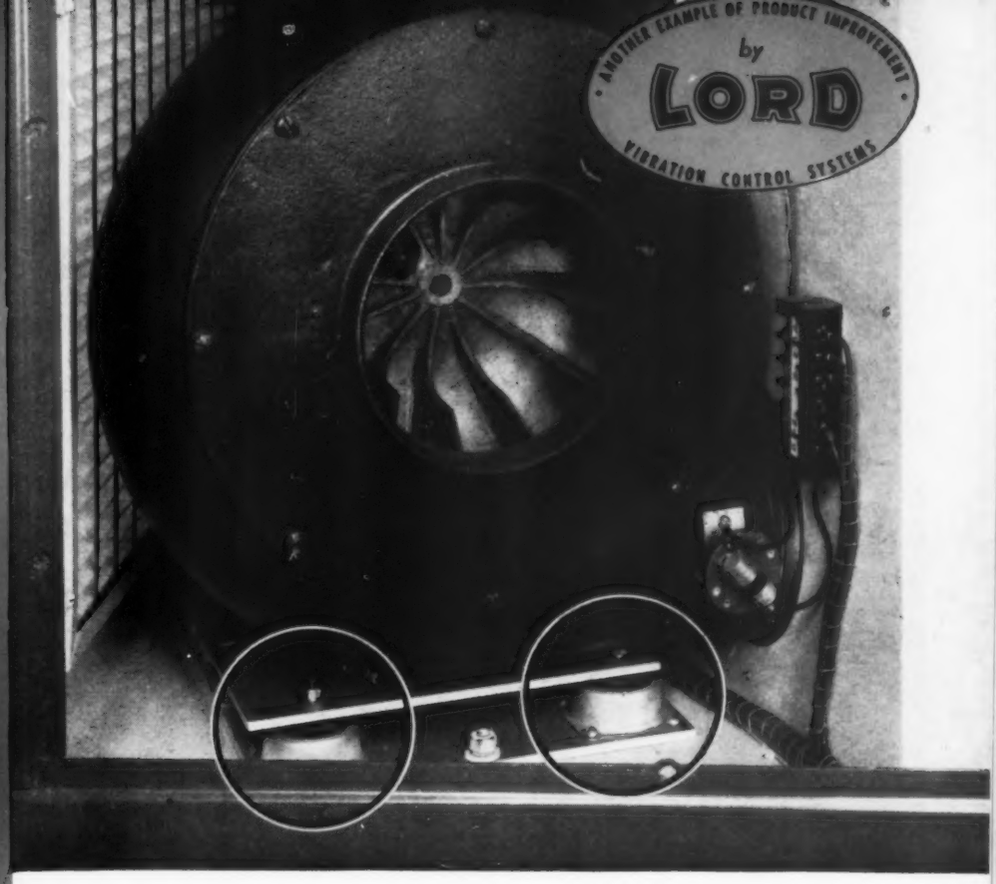
GIRDLER *Isolates Blower* VIBRATION *with* LORD VIBRATION CONTROL SYSTEM



Above—Thermex Model 10-H high frequency heat generator used for high speed wood-glue bonding. Lord Mountings isolate blower vibration from sensitive equipment.

Below—Lord Vibration Control System in Thermex Model 10-H also includes Mountings for oscillator tube. Complete protection prolongs tube life—cuts operating costs.





***LORD** Mountings Used by The Girdler Corporation in Thermex High Frequency Heating Equipment to Isolate Blower Vibration—Protect Oscillator Tube—For Greater Efficiency, Service Life . . .*

Greater efficiency—longer service life—smooth, quiet performance are obtained in Thermex high frequency heating units by thorough isolation of vibration. Protection of sensitive electronic equipment from vibration is so important that The Girdler Corporation, Thermex Div., specifies a *complete* Lord Vibration Control System in their product.

The Lord Vibration Control System in this Thermex unit provides two-way protection . . . first, by isolating blower vibration, and secondly—for complete protection—isolating the sensitive oscillator tube from external vibratory disturbances. Four Lord Shear-Type Bonded-Rubber Mountings under the blower and motor assembly prevent its vibration from damaging the oscillator tube. Three more Lord Mountings support the oscillator tube, effectively guarding it against shock and vibration from nearby machinery.

Whether you manufacture electronic equipment or any other product, you can increase your sales by eliminating costly, destructive vibration. It will pay you to consult Lord . . . make us your headquarters for product improvement through Lord Vibration Control Systems.

LORD

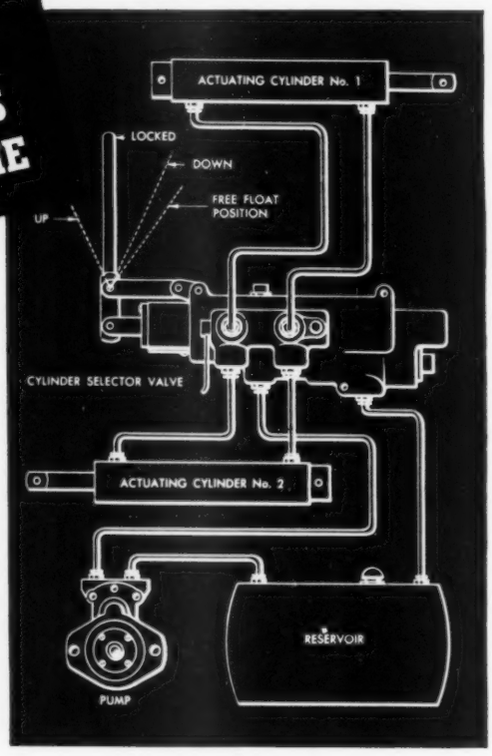
MAKE GOOD PRODUCTS BETTER
with *Vibration Control*

LORD MANUFACTURING CO. • ERIE, PA.

Field Offices: Detroit • Chicago • New York • Washington, D.C.
Providence, R. I. • Burbank, Cal. • Philadelphia, Pa.
Canadian Representative: Railway & Power Engineering Corp., Ltd.

ADEL *Hydraulic Equipment*

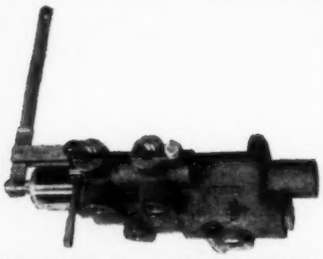
HOW TO DO TWO THINGS AT ONE TIME



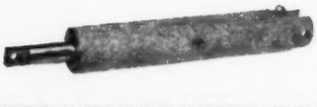
Here's a blue print for doing *two* operations at once. A simple hydraulic system, consisting of a reservoir, pump, valve and two actuating cylinders.

A special feature of this system is the new Adel Open Center Selector Valve. It controls both actuating cylinders, simultaneously or individually. Loads may be hydraulically locked in any position, or be set for free movement. It affords high speed operation, for lifting or lowering.

OPEN CENTER 4-WAY SELECTOR VALVE—Built-in rotating selector valve permits individual control of two actuating cylinders. The main slide valve has four positions: *up, locked, down* and *free floating*. The handle is "spring-loaded" and automatically returns to the *locked* position. A detent holds the handle in the *free floating* position. Internal relief valve is preset for specific application requirements. Maximum operating pressure, 1000 psi.



HYDRAULIC ACTUATING CYLINDER—Double acting type. Rugged construction; withstands high loads. Seals are easily and quickly replaced. Special brass scraper ring cleans foreign matter from piston rod; protects the system.



HYDRAULIC POWER PUMP—A new, gear-type hydraulic pump. At 2250 rpm, this compact unit delivers 12.5 gpm at 800 psi. May be direct-connected to motor, or belt driven.

Adel stands ready to work with you on any problem in the field of hydraulics. At your service are Adel's years of experience, extensive manufacturing facilities and practical engineering skill. Address Adel Precision Products Corp., 10757 Van Owen Street, Burburbank, Calif.

ADEL

ADEL PRECISION PRODUCTS CORP.
BURBANK, CALIF. • HUNTINGTON, W. VA.

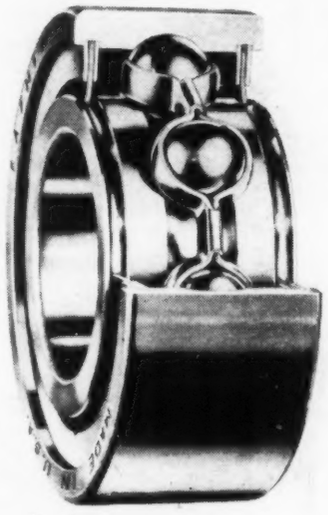
Manufacturers of: Aircraft Hydraulic Systems • Marine & Industrial ISOdraulic Controls • Halfco Self-Aligning Bearings • Line Support Clips & Blocks Industrial Hydraulic Equipment • Aircraft Valves • Industrial Valves

preformed wire curves. It is possible to produce almost any shape desired, including reverse curves, to meet the needs of engineers, designers, draftsmen, and architects. The wires are easily and quickly interchanged by snapping loops over the ends of the adjustment screws. The Infinarc is made entirely of stainless steel.

Wide Ball Bearings

The Fafnir Bearing Co., New Britain, Conn.

Designated as W-PP, the Wide Type Plya-Seal Ball Bearings have the same width as the standard double row ball bearing but only a single row of balls. Plya-Seals are provided on both sides for retention of lubricant and exclusion of foreign materials. The principal advantage claimed for the new bearing is the fact that it is a self contained anti-friction unit carrying a large sealed-in supply of factory packed grease ample for years of operation. Use of a single row of balls in a double row width provides space for a long time supply of grease without total filling, thus permitting "breathing", grease expansion caused by aeration and agitation under



You can turn a shaft by foot

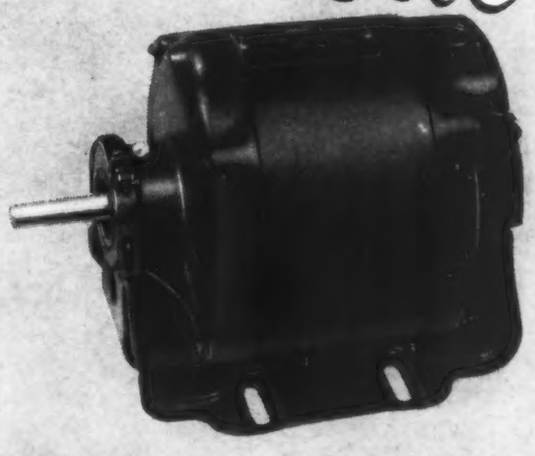
BUT IT'S BETTER TO USE YOUR HEAD

Appliance manufacturers know that Delco motors are an intelligent choice to "turn a shaft" in their products. Delco motor dependability has been proved over the years on leading makes of refrigerators, washers, ironers, stokers, oil burners, air conditioners and other appliances.

This fine performance record has won the complete confidence of appliance users and appliance dealers. The name "DELCO" on a motor assures them of sound engineering, quality materials, honest craftsmanship.

For a compact "power package" that meets specific requirements of torque and duty, you can't beat Delco motors. They are built in sizes from ⅛ h.p. to 50 h.p. Delco Products Division, General Motors Corporation, Dayton, Ohio.

Specify DELCO MOTORS

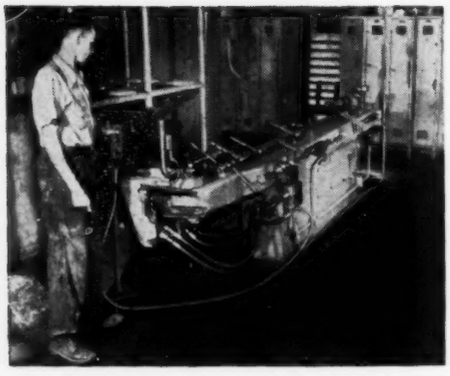


DELCO MOTORS
Power America's Leading Appliances

DELCO PRODUCTS
DAYTON, OHIO

Pines Bender Simplifies Operation . . . Results in 360 Bends per Hour

The PINES PRINCIPLE OF BENDING automatically produces uniform bends on a high production basis. On this job, three accurate bends are made in different planes without scratching the polished tubes at a production rate of 2 pieces per minute or 30 seconds for each piece. Prior production on other equipment produced less than one piece per minute. Each bend meets close tolerances, and in addition, less work is required of the operator.



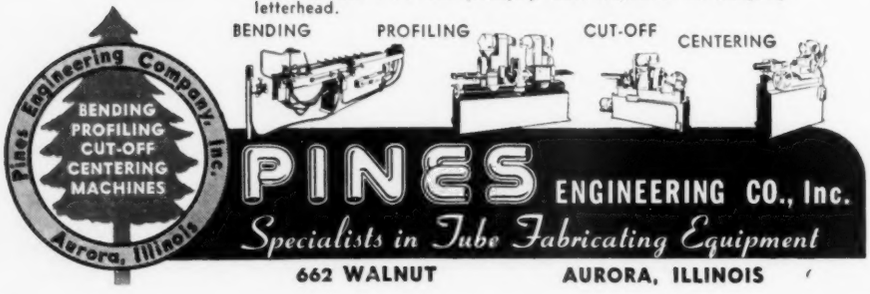
Accurate, Uniform Bends at Lower Cost

Every Pines Bending machine has ample capacity and power to produce a full-range of bends and handle heavy-walled stock. Built-in adjustment features permit ready adaption and increased flexibility to all types of SERPENTINE BENDS, STACKED COILS, RETURN BENDS, ROUND COILS, SQUARE and RECTANGULAR TUBES, SPECIAL ROLLED and EXTRUDED SECTIONS and other bent forms. Moreover, the Pines Bender is designed to produce bends to the accuracy required and without wrinkling.

Pines engineering service will show you how to produce quality bends on a high production basis and at lower costs. A comprehensive breakdown of the profitable advantages of the Pines Bender as applied to each of your bending requirements will be sent without cost. Send us information as to type of materials to be bent, maximum and minimum diameter, radius and degree of bend, etc.

Now

Write for your FREE copy of the NEW Pines Catalog . . . describing the PINES PRINCIPLE OF BENDING and the many Pines Benders . . . sent promptly when requested on company letterhead.



PINES ENGINEERING CO., Inc.

Specialists in Tube Fabricating Equipment

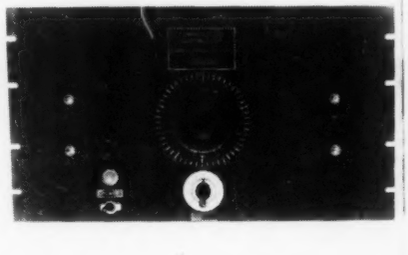
662 WALNUT AURORA, ILLINOIS

high speeds, without leakage. The double width insures better shaft and housing support, without slippage; the wide inner ring face provides "pull off" face area over standard shaft shoulder diameters. In the W-PP line, three piece Plya-Seals are used—each a synthetic rubber-impregnated sealing washer supported between two steel split retaining rings. The seal is impervious to grease and the common contaminants. Snapped into the outer ring with its supporting steel washer, it cannot bulge or buckle. There is wide clearance between it and the ball retainer. These bearings can be inspected easily since the seal can be removed with a penknife.

Temperature Controller

The W. S. Macdonald Co., 33 University Rd., Cambridge 38, Mass.

A proportioning electronic Temperature Controller is available which maintains the temperature of electrically heated ovens within less than 1/10 deg. F at temperatures up to 1,200 deg. Fahrenheit. This is done by electronic adjustment of the input power to the oven. The power flows continuously



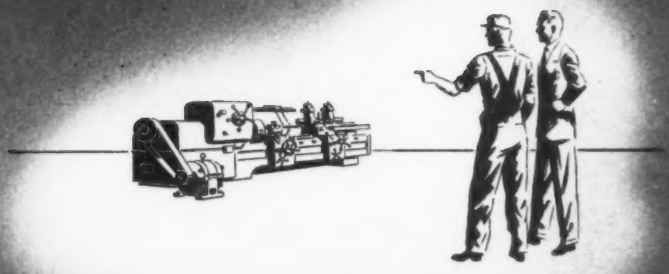
rather than in "on-off" cycles. Working temperature is reached rapidly because the instrument does not throttle power until the furnace reaches a point within 15 F of the preset temperature. Quick and accurate selection of temperature is made by means of a large vernier type dial. The controller operates on 110 v, a-c but can be used with furnaces requiring 110 or 220 v, a-c current. The unit is 19 x 10½ in. and can readily be adapted to particular installations.

Settling Tank Cleaner

Honan-Crane Corp., 916 Sixth St., Lebanon, Ind.

For completely automatic removal and transfer of sediment from settling tanks, without removal of fluid, a new mechanism, known as the Houdaille Conveyor, is now being produced. The conveyor is basically an endless link-chain, motor-driven, on which 4-inch neoprene rubber flights are mounted at 6-inch intervals. It operates through the V-bottom of the settling tank, trapping the

Ask your repairman what he thinks of Crocker-Wheeler protected-type motors



Here is an easy test of motor quality: Ask the man who has to keep your motors in running order.

You will find that the repairman has a very high regard for Crocker-Wheeler motors BECAUSE *he has had so few of them to repair.*

Crocker-Wheeler Protected-Type motors are recommended for use—

- **WHERE THERE IS DRIPPING LIQUID**
- **WHERE THERE ARE FALLING CHIPS**
- **WHEN INSPECTION VISITS ARE FEW AND FAR BETWEEN**
- **FOR ALL GENERAL PURPOSE APPLICATIONS . . . HORIZONTAL, VERTICAL OR WALL MOUNTED.**

Designed for the tough jobs, these motors are available in standard ratings, from 1 to 1,000 hp.

Ask for full information.

Quality Motors and Generators Since 1888

TAKE THE HEADACHE OUT OF BUYING AND SPECIFYING MOTORS

Ask for your FREE copy of this new 8-page price list. Gives prices, weights, dimensions of all the most commonly used motors, in standard ratings up to 75 hp:

SQUIRREL-CAGE MOTORS: *Protected-Type, Totally Enclosed Non-Ventilated, Totally-Enclosed Fan-Cooled, Explosion-Proof, Splashproof;* **WOUND-ROTOR MOTORS; DIRECT-CURRENT MOTORS:** *Constant-Speed, Adjustable-Speed.*

Also includes additions for bases, flexible couplings and control. Send for your copy today. CW-21

CROCKER WHEELER

ELECTRIC MANUFACTURING COMPANY, AMPERE, N. J.

A Division of Joshua Hendy Corporation

Branch Offices: Boston, Chicago, Cincinnati, Cleveland, Los Angeles, New York, Philadelphia, Pittsburgh — Representatives in Principal Cities.

AIRCRAFT ENGINES

get the RIGHT START when PERKINS GEARS "appear in the picture"!

● During the war, Perkins High-Precision Gears contributed to a considerable extent towards the superiority of America's military aircraft. While in the production of planes, the emphasis is now on transportation, many airplane engine manufacturers continue to depend on Perkins Gears for smooth, trouble-free power transmission.

● Our production equipment comprises modern machine tools, and our facilities are ample to meet practically any demands for the mass production and prompt delivery of precision gears. Once your specifications are in our files, reorders are filled automatically.

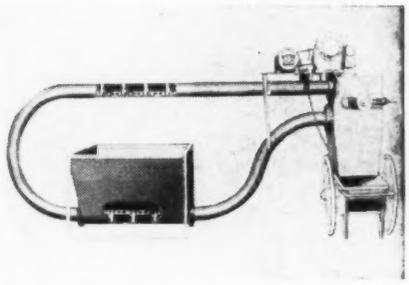
YOU FURNISH THE SPECIFICATIONS • WE'LL PRODUCE THE GEARS

PERKINS precision, custom-cut GEARS

Perkins Makes—in all materials, metallic & non-metallic
Helical Gears, Bevel Gears, Ratchets, Worm Gears, Spiral Gears, Spur Gears, Ground Thread Worms

PERKINS MACHINE & GEAR CO. • SPRINGFIELD 2, MASS.

sediment between the flights and conveying it through a 4-inch pipeline to a collection and disposal point. The conveyor turns sharply upward upon leaving the tank, thus allowing fluid to drain back. Sediment is carried along to the dumping point where the chain and flights emerge from the pipe and discharge the load while making a vertical turn on the drive-sprocket. Drive sprocket is mounted at the top of the collection hopper. The chain is pin-connected so that it can turn in any direc-

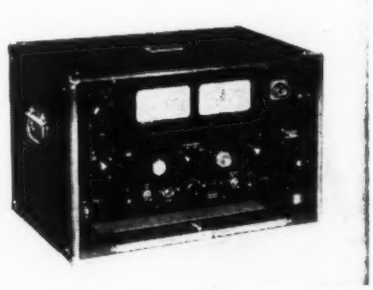


tion and thus follow any pipeline course. The conveyor is driven through a chain-and-sprocket transmission from an electric motor and gear reduction case. The speed of operation is about two to three feet per minute. The conveyor was developed to remove chips and sediment from settling tanks that form a portion of central purification systems for cutting oils and coolants used in metal-machining operations. It is equally suitable to any application in which it is desirable to remove sediment continuously.

Insulation Tester

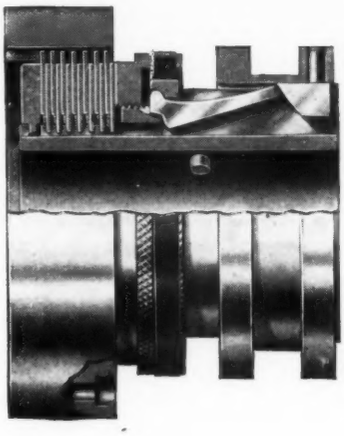
Radio Frequency Laboratories Inc., Boonton, N. J.

The Model 184 measures insulation resistance of power cables, transformers condensers, switches and wiring assemblies at any desired d-c voltage up to 10,000 volts. Breakdown voltages also can be accurately determined with a minimum of damage due to burning. Two separate circuits measure high re-



sistance at the desired test voltage. Speed in taking measurements is possible because of high current ranges, permitting rapid charging of capacitors and cables containing capacitance and rapid discharge of capacitance after test. Safety features include a relay for automatic and rapid removal of dangerous

69 EXHIBITORS AT MACHINE TOOL SHOW WERE MAXITORQ USERS!



MAXITORQ CLUTCHES were conspicuous "by their presence" in booth after booth . . . smoothly transmitting power on nationally known machines in operation.

This Floating Disc Maxitorq of ours was certainly in good company . . . and it is fast gaining new friends, new original equipment selections for varied types of machinery not on exhibition at the show.

And there are good reasons why . . . points of superiority in design principles, construction and adjustment, that are exclusively Maxitorq.

For instance; Separator Springs that "float" the discs apart in neutral to prevent drag, abrasion, heating. Manual adjustment, take-apart, assembly . . . no tools required. Then too, clutches are completely assembled on the body, shipped ready to slip onto a shaft.

There are many other Maxitorq details that machine designers and machinery manufacturers should know, and they are all covered in the new catalog available on request. Write us today for Cat. No. PE-12.

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

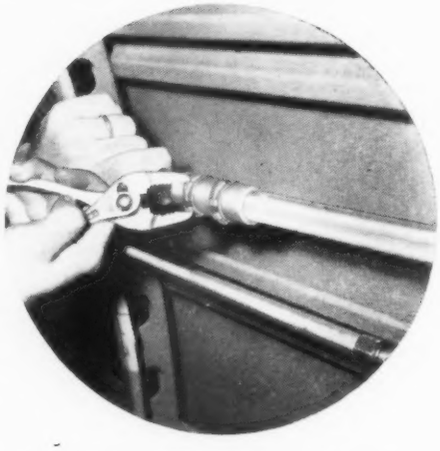
TASTELESS TUBING

A tubing problem existed in the development of Boeing's gigantic Stratocruiser, destined to land in all parts of the globe. Boeing engineers found that the mineral content in drinking water of some countries reacted badly on metal tubing, making the water unpalatable. After extensive research, they found that Tennessee Eastman's Acetate Butyrate material was not affected by any of these minerals. As a result, each Stratocruiser's drinking water system is equipped with this "tasteless tubing" extruded to specifications by MACOID.

★ ★ ★

For many installations, plastic tubing is far superior to metal. Some plastics are not attacked by minerals, acids, or chemicals. Some are flexible; others are rigid. Each use requires careful evaluation of properties to find the right material.

When a special problem in tubing is encountered, MACOID is equipped to select materials, design and mass-produce all kinds of thermoplastic tubing up to 2″ diameter in rigid materials and up to 6″ diameter in flexible vinyls.



Installation of MACOID tubing is easy. As pictured above, lightweight clamps seal the joints. Each Boeing Stratocruiser's drinking water system requires 435 feet of this tubing.

DETROIT MACOID CORPORATION

Originators of Dry Process Plastics Extrusion

12340 CLOVERDALE • DETROIT 4, MICHIGAN

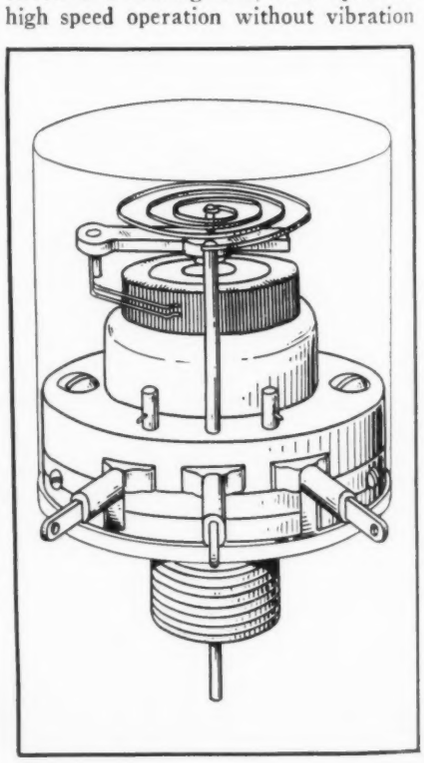
EXTRUSION AND INJECTION MOLDING

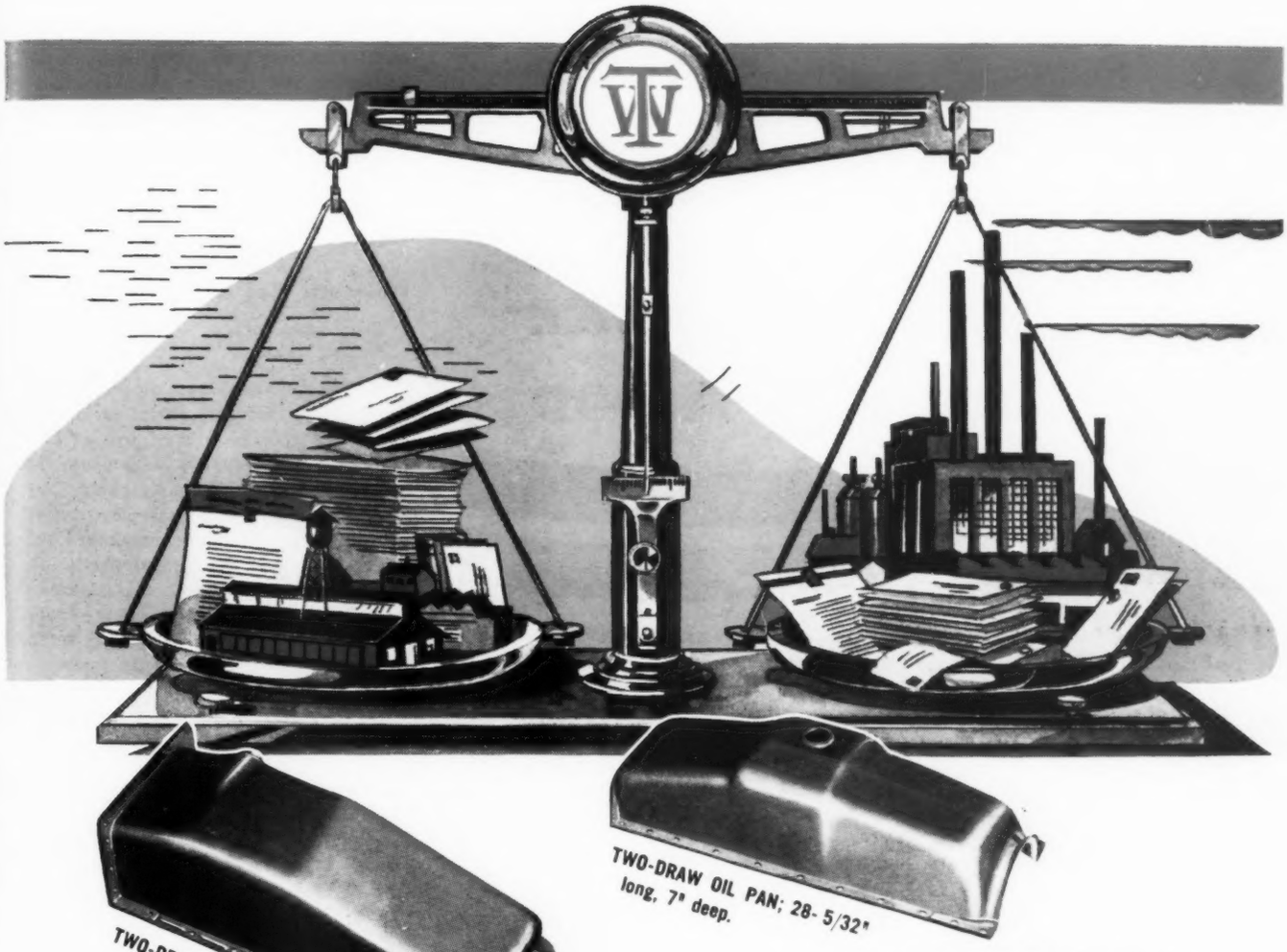
capacitance charges remaining on cables or condensers after test. A neon lamp protects the microammeter against overload if the output is short-circuited. Limiting resistors protect the power supply by limiting maximum current to 3 milliamperes. Overvoltage on the higher ranges is prevented by limiting resistors in the plate transformer primary circuit. Resistance ranging from 0.1 to 50,000 megohms can be read directly on a megohmmeter scale at open circuit voltages of 0.5, 1, 5, and 10 kv, or can be simple calculated in ranges from 0.3 to 20,000 megohms from the readings of a voltmeter and microammeter connected to read resistance at any desired test voltage from 100 to 10,000 volts. Housed in a heavy hardwood cabinet, this tester operates from a 115 v, 60 cycle line and consumes a maximum of 65 watts.

Miniature Potentiometer

Autoflight Insrtuments Div., G. M. Giannini & Co. Inc., 285 W. Colorado St., Pasadena 1, Calif.

In many instances it is necessary or expedient to operate an electrical circuit from an instrument that is already available but which lacks the necessary sensory signal element. Microtorque Potentiometers, ultra low torque variable resistance elements, can be used to energize remote indication and control circuits. This unit contains platinum or platinum alloy resistance elements, brushes and slip rings to provide low brush pressures with excellent contact; jewelled shaft bearings minimize friction. The low mass of moving parts reduces inertia effects and bearing load, which permits high speed operation without vibration





TWO-DRAW OIL PAN; 28- 5/32" long, 7" deep.

TWO-DRAW OIL PAN; 26- 21/32" long, 8- 1/16" deep.

ONE-DRAW CYLINDER HEAD COVER; 19- 1/8" long, 3- 1/2" deep.

BALANCED ENDORSEMENTS

ALMOST invariably, the manufacturer seeking a source of supply on steel stamping parts wants opinions of disinterested persons on reputations of stamping producers. It is a sound approach for the parts buyer who must rely on an outside supplier for such critical factors as unvarying accuracy, uniform physical properties and finish. Transue welcomes investigation of its own reputation. T & W parts users are enthusiastic in their endorsements of both Transue's rigid quality standards and reliable delivery. You will discover this important point about endorsements of Transue service, also—they come from a well balanced cross-section of parts users, show satisfaction among large and small buyers alike. Ask for names of Transue customers near you.

TRANSUE & WILLIAMS
ALLIANCE, OHIO

Designers and Makers of Deep Drawn Stampings

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different
AS ~~ALIKE~~
AS PEAS IN A POD

PEAS in a pod may look alike—but when you get right down to it, they're quite different.

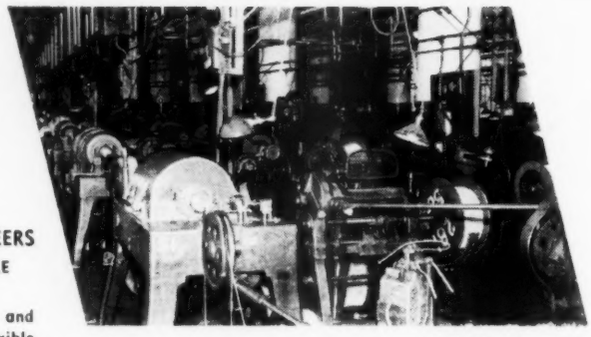
The same is true of flexible shafts. Superficially, they all look pretty much the same. It's in service that the differences quickly show up. You'll find that S.S.White flexible shafts operate with velvety smoothness, regardless of curves—that they retain their characteristics—that they do their jobs dependably—that they have a surprisingly long service life.

And what accounts for these differences? Well that's a long story — a story of S.S.White's more than 70 years of pioneering in the making and improving of flexible shafts. It boils down to this—S.S.White has the right answers to the factors which determine shaft characteristics and performance—such factors as—kind and grade of wire—number of layers—number and size of wires per layer—pitch of wires—tension on wires in winding—equal tension on all wires, etc., etc.

So when you need flexible shafts—either for power drive or remote control—it will pay you to get them from S.S.White. By so doing you make sure of years of efficient, trouble-free flexible shaft performance. And remember also that any time you want engineering co-operation on shaft applications, it's yours without obligation. Just write us.

FREE TO ENGINEERS
THIS 260-PAGE FLEXIBLE SHAFT HANDBOOK

It gives full information and engineering data about flexible shafts and how to select and apply them. Copy free, if you write for it on your business letterhead and mention your position.



Row on row of winding machines in S.S.White's Staten Island plant turn out millions of feet of flexible shafting annually. These machines, specially developed by S.S.White, assure accurate production of desired characteristics, uniformity throughout every length of shafting and above all *exact duplication of shafts of like specifications.*

S.S.WHITE INDUSTRIAL DIVISION
THE S. S. WHITE DENTAL MFG. CO.
DEPT. D 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED RESISTORS • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

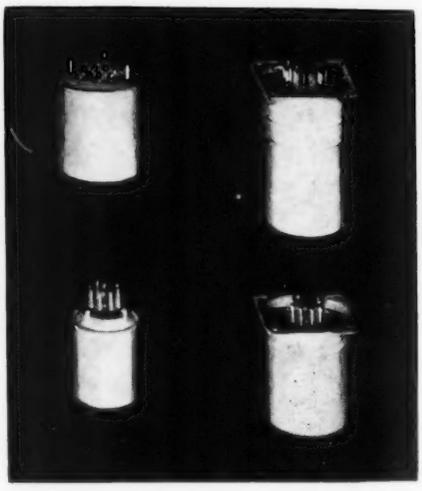
One of America's AAAA Industrial Enterprises

difficulties. This variable resistance element requiring only 0.003 oz-in. for its operation and capable of dissipating 2 watts is, in effect, an electro-mechanical amplifier of simple, accurate and dependable design. Microtorque Potentiometers are available with resistances from 100 to 15,000 ohms in units with a total weight of ¾ ounces.

Hermetic Sealing Process

Electro-Seal Corp., 946 Lee St., Des Plaines, Ill.

Precision electrical and mechanical devices are hermetically sealed to increase usefulness and life, and to provide freedom from maintenance. This protection from external conditions is being supplied for relays, transformers, choke coils, pulse transformers, amplifiers, rectifiers, crystals, vibrators, flashers, timers and other electronic and electrical equipment. The inclosure, base, brackets and terminals are designed by the Electro-Seal service, manufacturing or



supplying the component parts, after which they are assembled, wired and sealed. A high vacuum exhaust removes all moisture and air from the inclosure. Test is made for possible leaks while the unit is under high vacuum. The inclosure is filled with nitrogen, air or other desirable gases or liquids. This provides the ideal working condition within the inclosure, and allows the product to function free from the effects of moisture, altitude, dust, dirt, oil, insects, tampering and combustible or corrosive gasses. Illustrated are four of the standard inclosures now available.

Fluid Line Coupling

The Hansen Mfg. Co., 4031 W. 150th St., Cleveland 11, Ohio.

A quick-connect and disconnect coupling, both members of which seal automatically when disconnected, is known as the Hansen Series 8000, and combines two-way shut-off with simple, rapid and safe connecting and disconnecting on hydrau-

GOT WEIGHT ON YOUR MIND?

DESIGN FOR A BONUS IN LIGHTNESS

MACHINING COSTS come down when you use American Magnesium. Magnesium can be cut as fast as your machines can work—and faster.

FAST SPEEDS, FAST FEEDS; the job revolves fast and the tool moves fast with magnesium. You can deep cut.

FINE FINISH means less time needed. With magnesium you get the end result in less time, with fewer operations.

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Magnesium can be welded, stamped, cast, forged, extruded. Wherever it is used, it pays its way. More and more American Magnesium is being engineered into more and more types of products. Many intricate, semi-fabricated shapes can be easily incorporated into designs. You've nothing to lose by investigating. Write or call your nearest Alcoa Sales Office. ALUMINUM COMPANY OF AMERICA, Sales agent for American Magnesium Products, 1702 Gulf Building, Pittsburgh 19, Pennsylvania.

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FOR SEMS WASHER SCREW ASSEMBLIES

Washer permanently fastened on, yet free to rotate. Easier, faster driving. No fumbled, lost or forgotten washers. Matching finish on both parts. Easier ordering and balanced inventories.

FOR PHILLIPS RECESSED HEAD SCREWS

Increase assembly speed up to 50%! Cut down injuries to workers with no burrs, no skids. Reduce production costs. Reduce rejects! Improve product appearance! Go modern with Phillips!

FOR CLUTCH-HEAD SCREWS

The latest type recessed-head screw. Screw locks on driver. Can't fall off. No screw-driver slippage. Easy to assemble. Exceptional driver life. Ordinary screw-driver may also be used.

FOR SPECIAL COLD-FORGED FASTENINGS

Scovill is expert in cold-forging unusual special fastenings, such as the one shown. Scovill designing ability, engineering skill, men and machines save money for customers. Consult Scovill!

Look at the fastenings you're now using—and see if they're the best for the job. Get better results—at less cost—with modern fastenings. If you use fastenings in *large quantities*, it will pay you to find out what Scovill can do for you. Fill out and mail the coupon below—*now!*

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QUALITY FASTENERS FOR QUANTITY CUSTOMERS

SCOVILL MANUFACTURING COMPANY
WATERVILLE SCREW PRODUCTS DIVISION (PE-12)
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- ☐ Scovill SEMS Washer Screw Assemblies
- ☐ Scovill PHILLIPS Recessed Head Screws
- ☐ Scovill CLUTCH HEAD Screws
- ☐ Scovill Special Cold-forged Fastenings

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COMPANY_____

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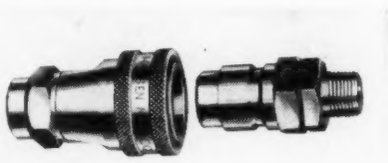
lic or pneumatic lines. Valves are located in both socket and plug. Both valves are opened automatically by inserting the plug into the socket, and will allow fluid to flow in either direction. There is an "O" ring seal between socket and plug when connected. Flow area through the valve is adequate, and because of the streamlined interior, pressure drop is not excessive. The valves

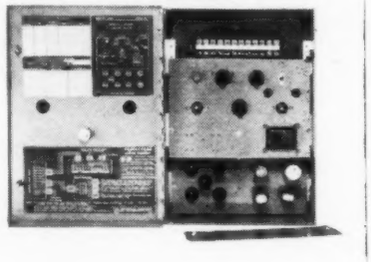


in this series will prevent loss of fluid from both ends of the line. The coupling is recommended for ⅜ in. lines, but for convenience, the socket is made available with ⅜, ½ or ¾ in. female pipe thread, male pipe thread, hose stem or hose clamp connections and the plug can be had with ⅜ or ½ in. female pipe thread, male pipe thread, hose stem or hose clamp connections.

Automatic Cut-Off

The Brinnell Co., Granby, Conn.

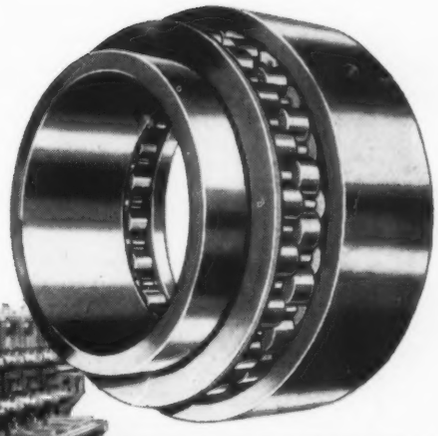
The Protectron is an electronic device for use in conjunction with an electric motor driven machine to trip at any pre-set mechanical overload. It is instantaneous in action, sensitive to minute overloads, and adjustable to any degree of overload within practical limits. However, the unit automatically compensates for fluctuations in terminal voltage. When the Protectron trips, a red trip warning light is illuminated, and a relay is energized to initiate any de-

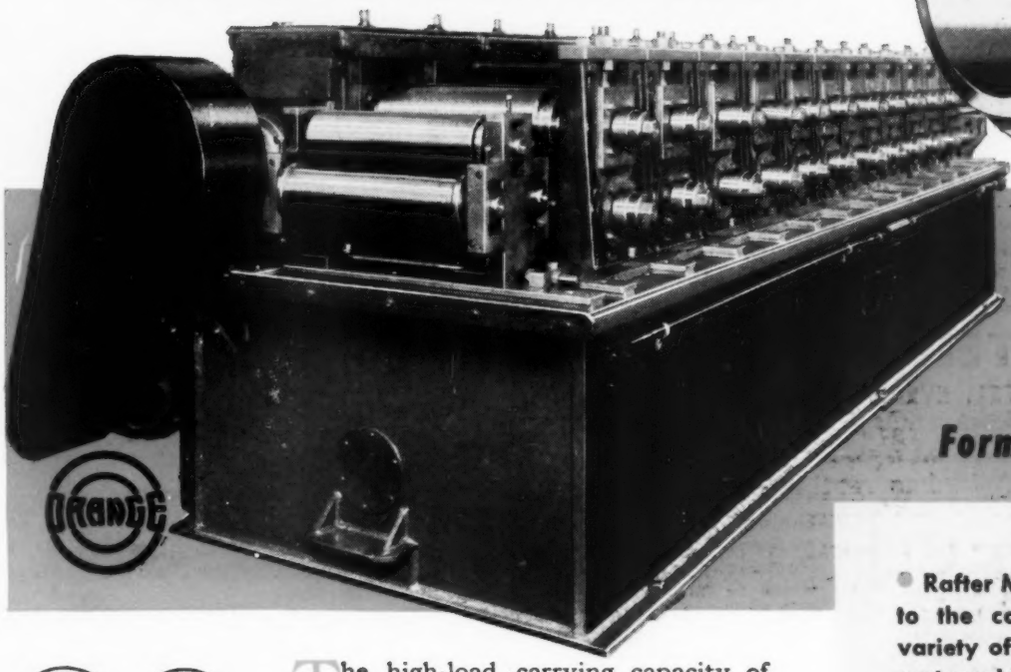


sired control function. It can stop the motor, stop the machine by operating clutch and/or brake, increase or decrease voltage on motor, sound warning signal or energize other auxiliary equipment. This unit prevents jamming in automatic machinery by "sensing" slightly over-sized stock, pile-ups, dull punches and other causes before damage occurs. By tripping at a pre-set degree of dullness, the Protectron enforces the sharpening of tools, thus increasing tool life up to a claimed 500 percent. Fur-

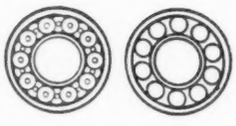
Close Tolerance under High Stress

ORANGE
"STAGGERED"
ROLLER BEARINGS





used for over 10 years in RAFTER Cold Roll Forming Machines



Shown above are end views of an Orange Staggered Roller Bearing and a conventional bearing. Note how staggered design brings maximum roller surfaces in contact with load.

The high-load carrying capacity of Orange Staggered Roller Bearings makes them especially valuable for heavy duty installations. They do the work of larger-size conventional bearings and stand up longer under severe operating conditions.

The exclusive staggered roller design provides maximum supporting area in minimum space. Smooth, precision running is assured, due to ease of alignment and adjustment of rolls in the raceway load area. Spaces between rolls act as lubrication pockets.

Orange Staggered Roller Bearings are made in a **full range of standard sizes, interchangeable with other solid race type bearings,** and carry the same identification numbers. Send for Engineering Data Book which shows design, dimensions, capacities, etc.

Rafter Machines are adaptable to the cold roll forming of a variety of steel partitions, refrigerator cabinets, metal door frames and other steel sections. Orange Staggered Roller Bearings are installed in the outboard housing supports because of their close tolerance and high load-carrying capacity. The Rafter Machine Company, Belleville, N. J., reports perfect satisfaction with the smooth-running accuracy and stamina of these bearings after 10 years of continuous service.

ORANGE ROLLER BEARING CO., INC.
551 Main Street, Orange, N. J.

Mail Coupon for Engineering Data

Orange Roller Bearing Co., Inc., PE
Orange, N. J.

Please send me your Staggered Roller Bearing Data Book

Name..... Title.....

Company.....

Address.....

City..... State.....

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Metal spinning the "Teiner" way will enable you to simplify designs and speed up production. In small runs you can save the cost of expensive dies and castings.

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An unusual and important part of "TEINER" service is the spinning of stainless steel. Here again, spinning eliminates the need for expensive castings and machining. It will be to your advantage to submit drawings or samples of your parts for a cost estimate of producing your requirements by spinning. Your inquiries are solicited.

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Stamping....Fabricating....Assembling....Soldering....Silver Brazing....Lacquering....Welding..etc. TEINER assures expert work in all metals and in any quantities, exactly to specifications. Our engineers are ready to cooperate with you on your needs.

ROLAND TEINER COMPANY

TEL. EVERETT 2669

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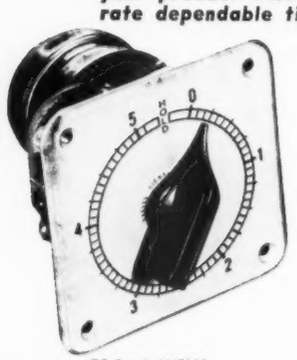
The New EAGLE MANUFLEX TIMER

For use on battery chargers, washers, extractors, etc.—any electrically energized machine which is turned "ON" manually and runs a predetermined time.

Increase the sales appeal of your product with this accurate dependable timer.

BACK VIEW

Mechanism enclosed in clear view plastic case



FRONT VIEW

features

- Synchronous Motor Driven eliminates springs and escapements
- Heavy duty silver contacts
- Flush mounting from front panel
- Screw terminals—no soldering for wiring connections
- "HOLD" position (Switch "ON" without timing) optional
- One hole mounting optional

Write for Bulletin 315 or consult Eagle sales representatives for further information. Bulletin 291 describing other Eagle Industrial Timers sent upon request.

EAGLE Signal Corp.
MOLINE ILLINOIS

ther, it avoids refinishing work with burrs caused by dull tools. The Protectron is available for 220/440 v, 60 cycle motors in two models; for operating currents of 1 to 5 amp and 5 to 10 amperes. Special models are available for higher operating current, higher voltage or 25 cycle operation.

Rubber-Spring Mounting

The Korfund Co. Inc., 48-12 32nd Place, Long Island City 1, N. Y.

Designed primarily for use on compressed units, generator sets, motor generators, pumps, motors and fans, the Korfund Type RS Conical Rubber-Spring Mounting provides greater horizontal stability than all-rubber mount-

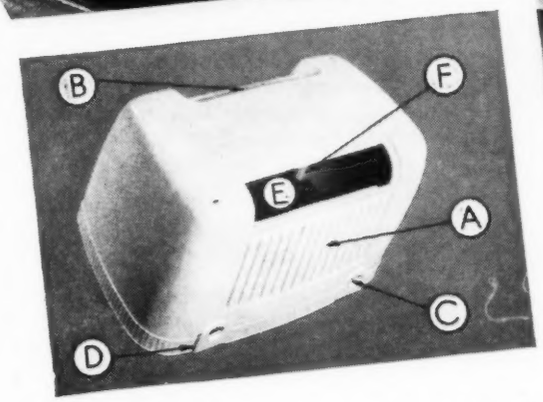
ings. This gives smoother operation, particularly during starting, and frequently eliminates the necessity for snubbers or flexible connections. The combined use of rubber and steel in this vibration control unit, not only increases the load capacity but also gives a wide frequency range for successful isolation. It is as effective for pumps operating at 1,750 rpm as for compressors running at 450 rev per minute. These units have load capacities ranging from 25 to 125 lb per unit.

Small Sealed Switch

Micro Switch Corp., Freeport, Ill.

A sealed precision switch with adjustable roller arm actuator, this unit is used in industrial equipment where it is exposed to dust, dirt, abrasives and the occasional splash of oil or water. The type N2 Die Cast Enclosed Switch

RADIO CABINET OF IMPROVED UREA
molded by Aico



Molding Material
An improved urea-formaldehyde material was chosen for its rich, lustrous color, exceptional strength, light weight and smooth, hard finish.

Molding Method
Cases are compression molded in semi-automatic molds. Special pre-heating of the material speeds the molding cycle . . . reduces cost by increasing production

Mold Design
The molds have been greatly simplified by designing the grill (A) so that it will draw, avoiding loose pieces in the mold. The molded-in handle (B) is made without moving parts in the mold. Holes (C) for control knobs are formed by movable core pins. Heavier cross sections (D) provide strength at points of stress. Close tolerances must be maintained at opening (E) which receives dial Structural strength is increased by reinforcing ribs (F)

Write for Aico portfolio of file cards

Soft, lustrous Ivory finish . . . as it comes from the mold

For this new Bendix Radio Cabinet, *Aico* engineers recommended the use of an improved Urea Material . . . Its rich, Ivory finish is equally at home in the kitchen, drawing-room or boudoir . . . it will not chip, peel or discolor with age.

Because *Aico* engineers have had over 30 years of plastics experience, they were able to mold this cabinet from the *one* material which could provide the desired Ivory color. Perhaps you have been considering the use of Plastics to improve your product. Why not rely on a molder of *proven* ability to guide you! We will be happy to be of service.

AMERICAN INSULATOR CORPORATION
New Freedom, Pa.
SALES OFFICES: Cleveland — Detroit — New York — Philadelphia

AICO **PRECISION MOLDING** For over 30 years

many things are better because of plastics

Silicone News

DC SILICONES

Silicones Reduce Size and Weight of Totally Enclosed Non-ventilated Motors

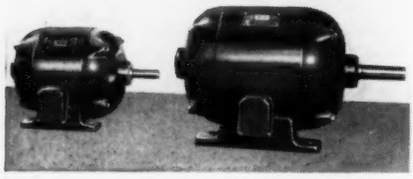


PHOTO COURTESY WESTINGHOUSE ELECTRIC CORP.

New 5 h.p. totally enclosed, non-ventilated Westinghouse motor (at left) protected with Silicone Insulation has same rating as much larger motor (at right) wound with Class A insulation.

This is the kind of industrial news we like to report. It's the story of that new Silicone insulated, totally enclosed, non-ventilated motor made by Westinghouse. This motor weighs only 60% as much as a comparable motor of conventional design. It requires no more space than an open motor of the same rating, and it is comparable in overall performance.

This very significant reduction in size and weight is a result of skillful designing to capitalize upon the exceptional heat stability of the silicone resins and varnishes developed by Dow Corning. These silicone varnishes are not affected by the somewhat higher operating temperatures which are caused by the relatively small radiating surface. The hottest spot temperature rise of this motor is within the 140°C. permissible for this new class of electrical insulation.

This new motor also incorporates another example of progressive engineering in the use of new materials. Its bearings are permanently lubricated with DC 44 Silicone Grease. Consequently, they require no attention for at least five years, in spite of the somewhat higher temperatures at which they operate.

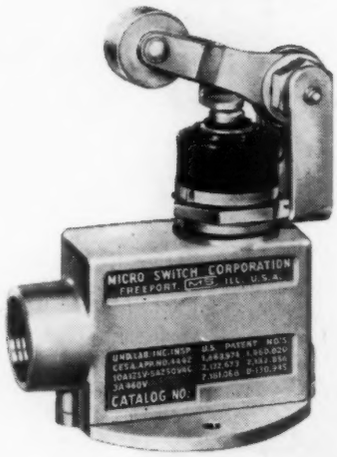
The introduction of this new Silicone insulated motor marks a new era in electrical insulation. The use of Silicone Grease in the bearings marks another major step in the direction of permanent lubrication.

Silicones have been responsible for all sorts of improvements in design and performance, ever since we started to produce them on a commercial scale nearly five years ago. Our experience in putting these new engineering materials to work is at your service. We'll be glad to send you our catalog C 1-6 which describes DC Silicone resins, greases, fluids and Silastic.*

*TRADEMARK FOR DOW CORNING SILICONE RUBBER

DOW CORNING CORPORATION
MIDLAND, MICHIGAN
New York • Chicago • Cleveland • Los Angeles
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES



is designed for cam and slide actuation, and the roller arm can be adjusted both vertically and horizontally. The switch is available with either bottom or side mounting flanges. The synthetic rubber boot covering the operating plunger and the gasket between the bottom plate and housing provide a completely sealed switch when the conduit hub is fitted with rigid conduit. The switch will operate with 6 to 16 oz forces, and can be released by a minimum force of 4 ounces. The pretravel is 11/64 in. and the overtravel is 7/32 in., while the differential movement is 0.006 inches.

Blower Wheels

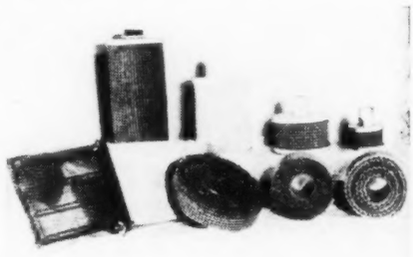
Revcor, 3227 W. Carroll Ave., Chicago 24, Ill.

These volume type blower Wheels were especially developed for use in oil burners, stokers, air conditioners and other blower applications. They are made of steel by a method of construction which also permits them to be made of brass or aluminum. Increased air output performance for the space dimensions and horsepower required is obtained with these wheels by the use of a large number of thin gage, full width blades of correct curvature and depth to provide maximum air contact for each diameter wheel. No rivets are used for holding the blades. The blade tips are expanded and rigidly locked in the slots of the inlet ring and back plate by a specially developed machine. The hub is riveted to the back plate of the wheel. Each wheel is balanced. Revcor Blower Wheels are now available in 5, 6, 7, 8, and 9 in. diameters, in 1 to 6 in. widths.

Liquid Strainers and Filters

Strainer Products Corp., 79 N. Willow St., Montclair, N. J.

Rapid advances in engineering applications of hydraulic machine control and operation have increased the development of, and interest in, liquid filters. Strainco strainers and filters have been produced which are capable of clarifying liquid from which particles on the order of microns must be removed. Since strainer elements can be furnished in any metal that can be drawn in wire form, round or flat, refills can be supplied for any size or type of housing. All filter and strainer units are designed to control the size of the particle passing through the medium without restricting fluid flow. These units are also available with magnetized mesh for separating microscopic particles from any liquid; including oils of high or low viscosity.

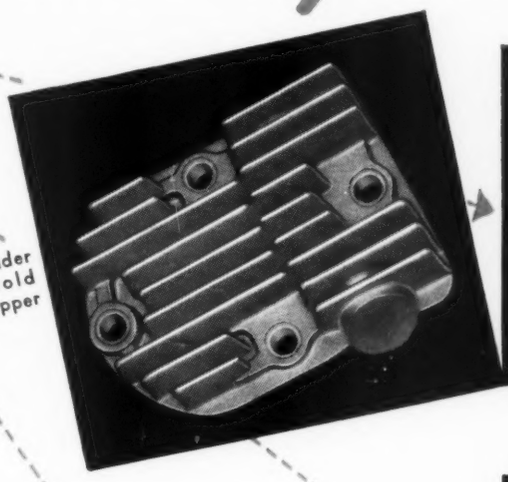


Universal Joint

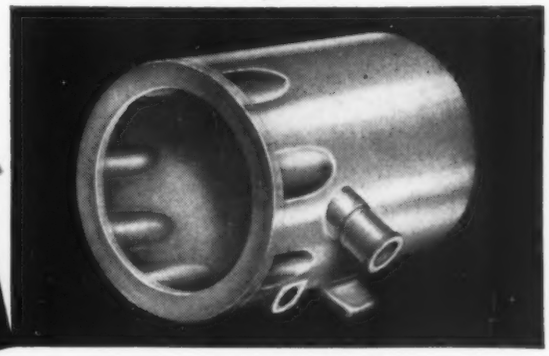
The Gear Grinding Machine Co., Conant Rd. and G.T.R.R., Detroit 11, Mich.

The Rzeppa Constant Velocity Universal Joint is claimed to be free from torsional vibrations at all operating angles and speeds. Briefly described, the joint consists of an outer driving member, of cylindrical or spherical shape, an inner, star-shaped driving member and a ball cage closely fitted between inner and outer drive. Assembled into a concentric arrangement, these parts are interlocked and yet free to swing relative to each other in the manner of a ball and socket joint. Each of the six balls, inserted in corresponding half grooves of both drives, transmits torque from one member to the other by free rolling action. The entire joint assembly is completely inclosed, oil being retained by a large tube, pressed on one member and connected to the other by a neoprene diaphragm. Rzeppa joints are

You WRITE your parts prescription and Permite will give you the RIGHT *Aluminum Alloy Casting*



Gasoline Engine Cylinder Head • Permanent Mold Casting • Aluminum - Copper - Silicon Alloy



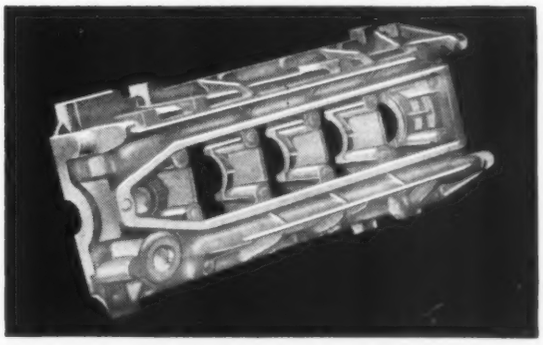
Household Pump Housing
Semi-Permanent Mold Casting
Aluminum - Silicon Alloy

When you submit your parts problem to the Permite organization you can be sure the aluminum alloy castings produced for you will have the characteristics and values you need for best results.

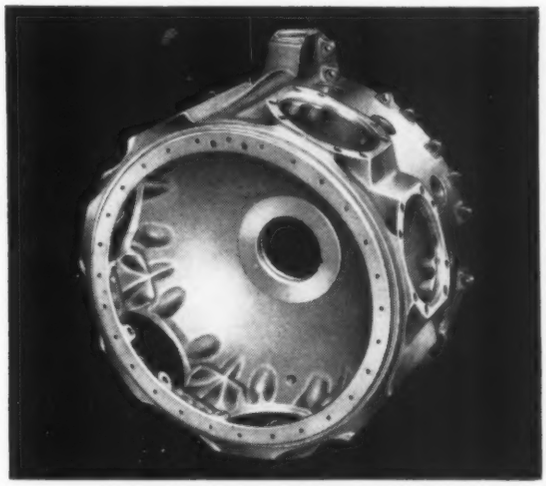
You can draw upon Permite metallurgical knowledge for selection of the alloys to give your aluminum castings the desired balance of tensile strength, corrosion resistance, yield strength, ductility or other physical properties.

And the preferred casting method for meeting your cost, quantity and design requirements, whether permanent mold, semi-permanent mold, sand or die casting, is afforded by Permite engineering experience plus modern pattern shop, tool room, laboratory and foundry facilities.

Send blueprints for recommendations and estimates on your aluminum castings requirements.



Automobile Engine Crankcase
Permanent Mold Casting
Aluminum - Copper - Silicon - Magnesium Alloy



Aircraft Engine Crankcase Section
Sand Casting
Aluminum - Copper - Nickel - Magnesium Alloy

PERMITE

ALUMINUM INDUSTRIES, INC.

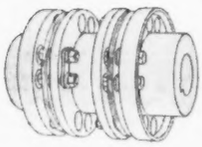
CINCINNATI 25, OHIO

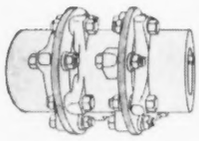
DETROIT: 809 New Center Building. NEW YORK: 9 Rockefeller Plaza. CHICAGO: 64 E. Jackson Boulevard. ATLANTA: 413 Grant Building

ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS...HARDENED, GROUND and FORGED STEEL PARTS

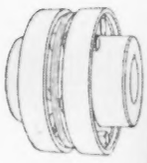
THOMAS Flexible ALL METAL COUPLINGS

Engineered to stand up on the toughest jobs, Thomas Flexible Couplings do not depend on springs, gears, rubber or grids to drive. All power is transmitted by direct pull.



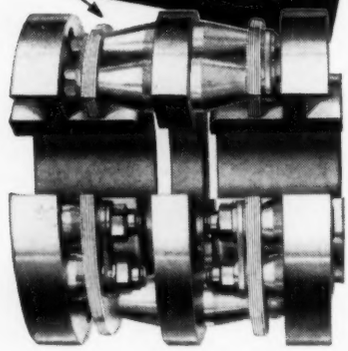


The standard line of Thomas Couplings meets practically all requirements. But if unusual conditions exist we are equipped to engineer and build special couplings.



BACKLASH FRICTION WEAR and CROSS-PULL are eliminated NO LUBRICATION REQUIRED!

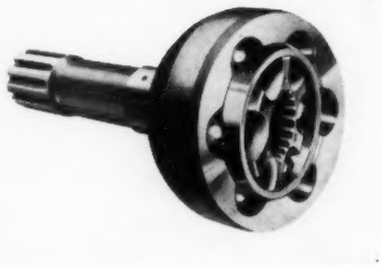
PATENTED FLEXIBLE DISCS



THE THOMAS PRINCIPLE GUARANTEES PERFECT BALANCE UNDER ALL CONDITIONS OF MISALIGNMENT

Write for New Engineering Catalog

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA



available in either Disc or Bell type in nominal sizes, corresponding with their drive shaft diameters from 15/16 to 2½ inches. The Disc joint, free to swing 18 deg, is especially suited for high speed propeller shaft drives where vibration is critical. The Bell Joint, capable of 37 deg deflection, is primarily designed as, power steering drive for front drive axles or articulated driving axles with independent wheel suspension.

Miniature Blower

Small Motors Inc., 2076 Elston Ave., Chicago, Ill.

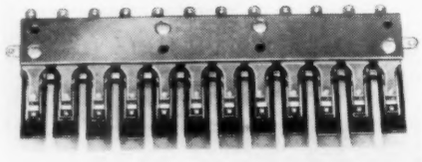
This small blower, designated the Bantam B-2 Blower, is used for ventilating and cooling electronic tubes, projectors and other small equipment. The Bantam Blower delivers 32 cfm and is

powered by a Small Motors universal fractional horsepower motor built for efficient, long-life performance. The complete unit operates from a 110 v, 60 cycle a-c line, and occupies a space of 5⅛ x 3½ x 3¾ inches. The motor will also operate from a 110 v, d-c line.

Gang Limit Switch

Acro Electric Co., 1310 Superior Ave., Cleveland 14, Ohio.

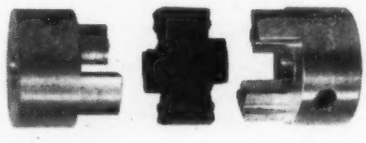
Designed for either cam or plunger operation, the 12 Gang Open Blade Switch that operates with the Acro Rolling Spring principle is manufactured as a single unit. This unit is permanently fastened together with countersunk rivets that permit flush mounting. The centerblade and rolling spring are made of heat-treated beryllium copper; all other parts are cadmium plated. The switch is available with normally open, normally closed or double-throw switches on any pole or combination of poles. Rated at 10 amp, 125v a-c, the switch can be operated by forces from 4½ to 6 ounces. Maximum movement differential is 1/16 in., with an overtravel of 1/16 in., minimum. The necessary force for release is 2½ ounces.



Flexible Coupling

The Climax Flexible Coupling Co., 863 E. 140th St., Cleveland 10, Ohio.

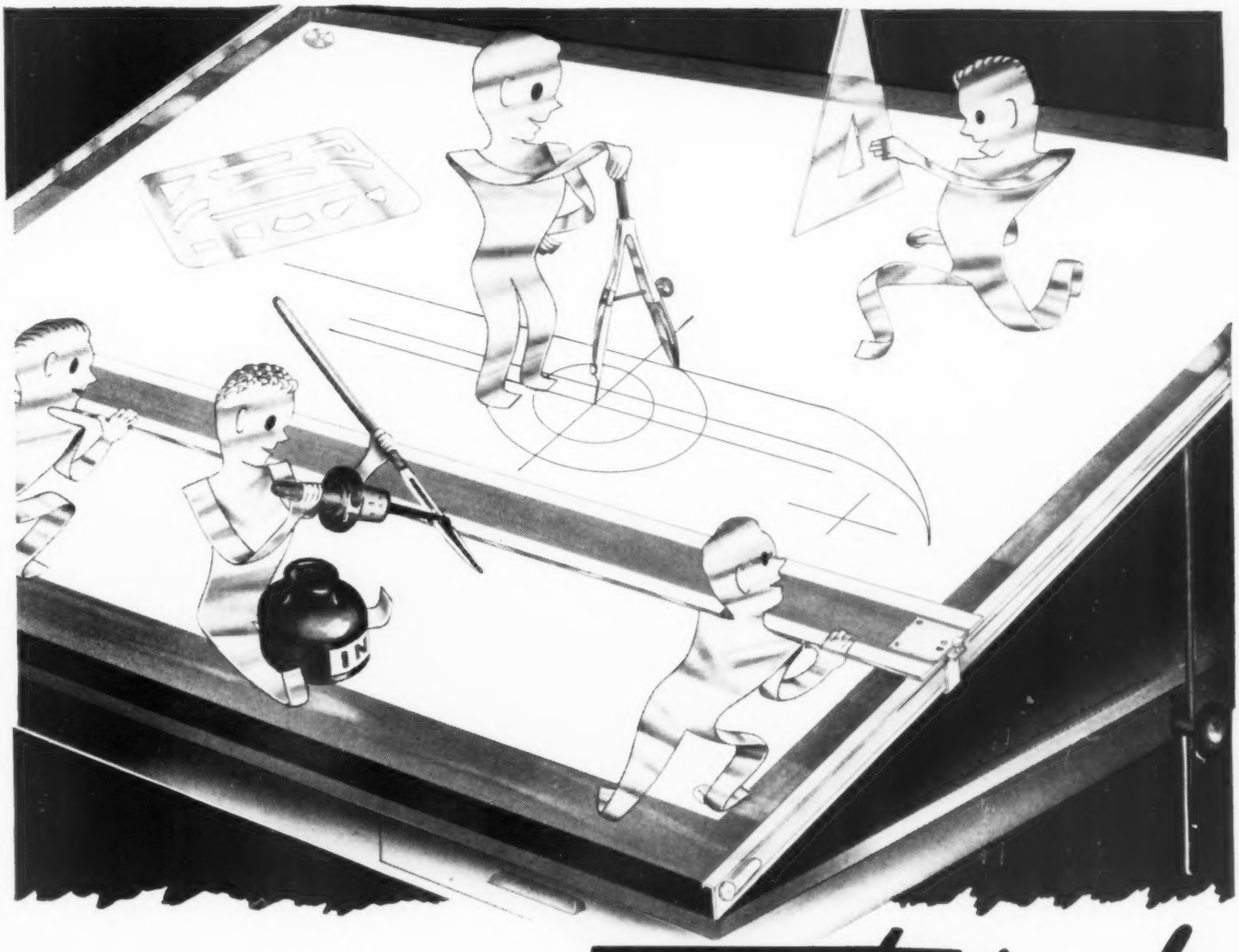
For light-duty installations, the Climax Type C flexible coupling is used exclusively with electric motor drives. The coupling is made of three parts: two identical, metal hubs and the rubber load-carrying insert. The coupling jaws dovetail with the rubber insert, which reduces extrusion, backlash, vibration and noise. The dovetail also increases the capacity of the unit because it increases the area of contact. This type of coupling has high flexibility and good capacity for shock absorption. The outside diameter of the metal hub is larger than that for the insert, and the hubs are accurately machined so that the coupling can be aligned by a straight edge. The three smallest sized couplings have die-cast bodies, and the three larger sizes have cast iron bodies. The capacities of the six units, at 1,750 rpm, range from 1/3 to 12 horsepower.



Plastic Bonded Rod

Wall Colmonoy Corp., 19345 John R St., Detroit 3, Mich.

This plastic bonded rod is a tough pliable material that can be used on the same reel, and in the same way as metallic wires, with no danger of breaking or pulling apart. It is used in wire metallizing equipment for applying overlays. Colmonoy Plastic Bonded Rod is composed of powdered Colmonoy No. 6, combined with a plastic binder, and extruded to size. As this rod passes through the flame of the metallizing gun, the plastic burns out, leaving the Colmonoy particles to deposit on the



WE DEAL IN TOMORROW . . . *Today!*

The ingots of raw aluminum feeding into our rolling mills today will become important components of tomorrow's finished products. To satisfy the varied industries which we serve, our work in design, in alloy, and in finish must always be months ahead of "today's" most modern advancement.

In the 49 years that we have worked with aluminum, we have come to know intimately its wealth of application. Over almost half a century we have equipped ourselves and trained our men to handle aluminum swiftly, effectively, and economically.

This knowledge and equipment, plus the developed skill of the "metal men of Manitowoc," is at your command. Use it today, for *your* tomorrow.

A CONTRACT PLACED WITH US EXPANDS *YOUR* PLANT TO INCLUDE:

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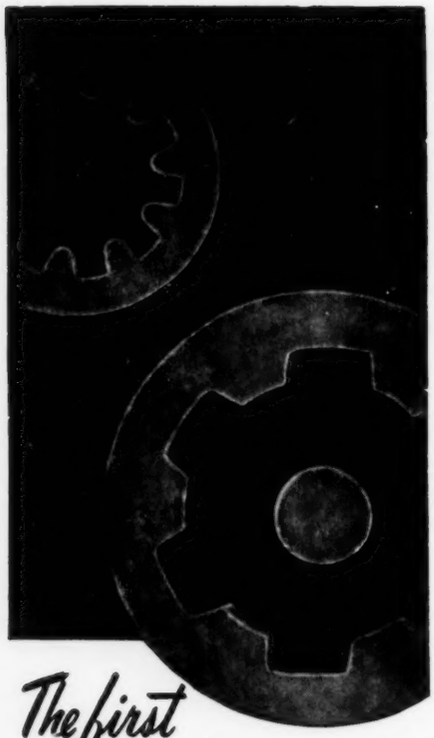
ALUMINUM GOODS *Manufacturing Company*

MANITOWOC WISCONSIN

FIFTH AVENUE BLDG., NEW YORK 10 MERCHANDISE MART, CHICAGO 54



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EXACTLY THE SAME!

Precision dies and precision methods at Booth's produce felt parts of consistent accuracy.

Add to this our high standards of quality plus prompt, interested attention to all orders, small or large, and you've a picture of the kind of service you get from Booth.

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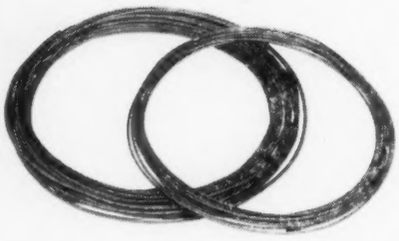
PRECISION CUT FELT PARTS



surface being sprayed. After the desired amount of overlay has been applied, a minimum of 0.01 to maximum of 0.125 in., it is bonded to the base metal by means of a large oxygen-acetylene torch, induction equipment or a controlled atmosphere furnace. With any of these methods, the final result is a molecular bond between the Colmonoy and the base metal identical to that obtained when the same alloy is applied in rod form. The rod is available in 5 lb coils with diameters of 1/8 and 3/16 inches.

Sketching Paper

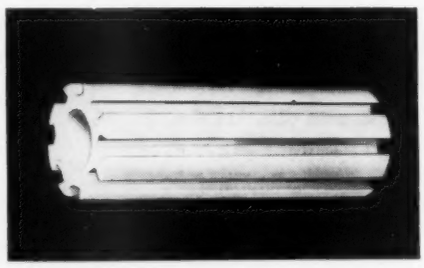
The Ogilvie Press, 691 Fulton St., Brooklyn 17, N. Y.

The cross section ruling on this sketching paper will not reproduce when the sketch is used as the original for blue print, black and white or Ozalid reproductions. This tracing paper will not become brittle or discolor with age, and has good erasing qualities. It will withstand considerable handling and still retain its good transparency. This 8½ x 11 in. material is available in pads of 50 sheets with 4, 5, 8 or 10 vertical and horizontal lines to the inch. Individual headings and forms can be printed to specifications.

Universal Coil Form

Henry L. Crowley & Co. Inc., 1 Central Ave., West Orange, N. J.

Avoiding special holes to take leads or mount terminals, this universal, ceramic coil form can be used in place of



special forms. The dovetail grooves make it possible to attach the tap lead to any part of the coil and have it come out at either end of the form. Spring clips can be slid along the form to any point where a terminal or tap connection is desired. The clips can be cemented firmly in place. The finished coils can be easily mounted on metal bases with prongs that fit into the ends of the grooves. Made of steatite, this coil form has low-loss performance and maximum stability regardless of temperature or humidity. For iron core tuning, a cap can be snapped over the end of the form and tapped in the center to hold the core screw for adjusting the core position relative to the windings. This fluted form is also applicable to wire-wound resistors either as the supporting core or as the cover for high-wattage resistors. The grooves provide good heat dissipation and can be used to hold printed or colored identification tabs in the latter case.

Time Totalizer

The R. W. Cramer Co., Inc., Centerbrook, Conn.

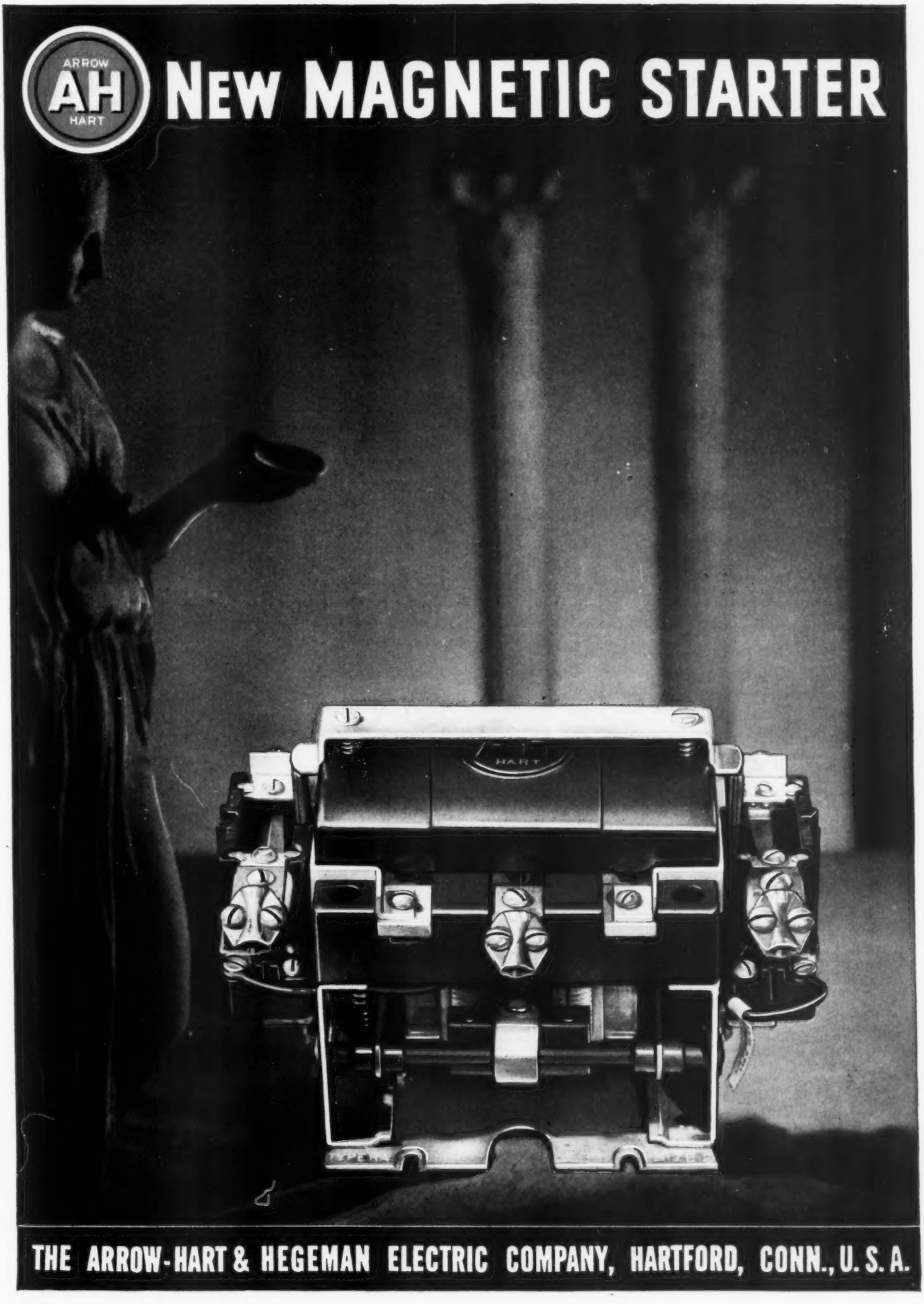
Designed for use on a-c circuits, these meters automatically register total operating or idle time of any circuit, machine or system to which connected. They feature a counter that can be reset to zero. These meters can be used to indicate operating time so that main-

tenance schedules can be followed and parts replaced before failure. Running Time Meters, as they are sometimes called, can be used to check operating hours of equipment used in time-testing materials or machines in the laboratory. The table, panel and conduit connection models indicate in tenths up to 10,000 hours and then repeat. The Cramer Synchronous Motor used in these meters, of the slow speed, self-starting type, will start and operate on rated voltage plus 10 percent. They are provided with an adequate supply of sealed-in lubricant and require no special attention. These instruments are available for use on 50 or 60 cycle current at 110 or 220 volts.

All Welded Solenoid

General Electric Co., Schenectady 5, N. Y.

For use where powerful pull is needed in a small space, this small solenoid has an all-welded construction. This con-


ARROW
AH
HART
NEW MAGNETIC STARTER
HART
THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U. S. A.

Design for the Best in Ace Saran

TAKE FULL ADVANTAGE OF THESE* PROPERTIES IN MOLDED OR EXTRUDED PARTS, MADE BY ACE TO YOUR SPECIFICATIONS

GENERAL PROPERTIES

Specific gravity–1.68-1.75
Specific volume–15.8-16.6 cubic inches per pound
*Water absorption, 24 hours at 25°C. (77°F.) –0.00%
Water absorption, 168 hours at 75°C. (167°F.)–0.5%
Water permeability–negligible
*Corrosion resistance–excellent
Effect of metal inserts–none
Machining qualities–good
*Burning rate–self-extinguishing
Fatigue resistance–excellent
Effect of sunlight–darkens slightly
Color possibilities–extensive

MECHANICAL PROPERTIES

*Ultimate elongation–15-25%
*Tensile strength, ultimate–4000-7000 lbs. per sq. in.
Compression strength, yield point–7500-8500 lbs.
Modulus of elasticity in tension x 10^5, range 0.7-2.0
Flexural strength–15,000-17,000 lbs. per sq. in.

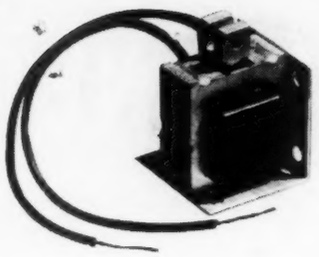
THERMAL PROPERTIES

Thermal conductivity–0.00022 cal/sec/cm²/°C/cm.
Specific heat–0.32 cal/°C/gm.
Resistance to heat (continuous)–satisfactory up to 175°F. (80°C.)
Heat distortion temperature–150-180°F. (66-82°C.)
Tendency to cold flow–slight
*Coefficient of thermal expansion–15.8 x 10^{-5}/°C.
Mold shrinkage, injection–0.008-0.012 in per inch
Resistance to impact lessens as temperature decreases. Brittle at very low temperatures

ELECTRICAL PROPERTIES

*Volume resistivity, ohm/cm at 50% relative humidity, 25°C. (77°F.)–10^{14}-10^{16}
Breakdown voltage 60 cycles, volts per mil instantaneous
3,000 volts per mil at 1 mil thickness
1,500 volts per mil at 20 mils thickness
500 volts per mil at 125 mils thickness
Power factor: 60 cycles, .03-.08; 10^3 cycles, .03-.15; 10^6 cycles, .03-.05

IF IT'S MOLDED OR EXTRUDED
Specify **ACE**
and send your drawings to
AMERICAN HARD RUBBER COMPANY
11 MERCER STREET, NEW YORK 13, N. Y.



struction reduces eddy current losses because the welds are outside the magnetic flux path. An L-shaped mounting bracket permits horizontal or vertical mounting. Frame and bracket are welded together for rigidity and long life. Frame laminations are of silicon steel, making possible more pull per watt input. High efficiency is achieved by welding these laminations together. The removable coil is sealed inside a plastic housing. It is paper layer wound, heat-treated to remove moisture, and impregnated with a plastic material. The unit is highly resistant to shock, splashing water, and oil. Plunger laminations of silicon steel are also welded. A new form of pole shader, brzaed into place, provides maximum quiteness at a lower watt consumption. This solenoid develops a maximum pull of 0.26 lb in a ½ in. stroke. It operates on 110 v, 60 cycle current.

Curvimeter

The Herman H. Sticht Co., Inc., 27 Park Place, New York 7, N. Y.

The Minerva Curvimeter, developed in Switzerland, measures distance accurately by tracing the instrument wheel along the lines of a blue print or plan. Three scales are shown on the dial face; ⅛ in. equals 1 ft, ¼ in. equals 1 ft, and ½ in. equals 1 foot. The most commonly used scale, ¼ inch, is marked in red. The scales measure distances up to 600 ft for the ½ in., 1,200 ft for the ¼ in., and 2,400 ft for the ⅛ inch. The hands can be reset by push button. The dial hands will move in both directions so that the lengths of incorrect lines can be subtracted by back-tracing. The contact wheel of this new instrument is mounted on two jewel bearings that give long wear and service.

Aluminum Surface Treatment

American Chemical Paint Co., Box 301, Ambler, Pa.

Used to keep aluminum quiescent in the presence of corrosive agents, the Alodine process is a chemical one requiring no electricity. A thin, tough skin, positively integrated with the metal, is formed by the interaction of aluminum and the Alodine chemicals. This skin has characteristics of stability, flexibility and adherence that enable it to withstand shocks caused by denting and bending. The chemicals can be applied by dipping or spraying to parts or continuous strips. The Alodine process coats and seals simultaneously and produces a surface that can be painted or that will resist corrosion by itself. Panels, Alodized and painted, have resisted salt laden atmospheres for over 2,000 hours. This coating can be applied in about 2 min. when the chemicals are heated to a temperature of 120 deg Fahrenheit.

Gas Detector

Jabez Burns & Sons Inc., 11th Ave. at 43rd St., New York 18, N. Y.

A protective device for gas-fired processing equipment, the Thermalo Gas Detector reveals the presence of flammable gases at concentrations below the danger point, indicates the degree of concentration on a dial and closes a

valve in the gas supply line. It functions when the machinery is not in operation as well as during the combustion cycle. The protection afforded by the gas detector is not limited to any one point. There is a continuous sampling of gases from as many parts of the processing unit as may accumulate flammable mixtures. There are no glowing filaments, and in most applications no motor or aspirator is needed. These detectors are available for any type of gaseous fuel: manufactured, natural, mixed or bottled gas.

THE CLOSED SHOP

Key to Labor Monopoly

IF THE PEOPLE of the United States are to loosen the monopoly control now exercised by some segments of union labor and recapture the power to control their own economic and political destiny, they must come to grips with the problem of the closed shop. A satisfactory solution of that problem is as vital to the interests of the wage earner, who should be fully protected in his right to organize and bargain collectively through representatives of his own choosing, as it is vital to the interests of the nation as a whole.

By the closed shop, which unfortunately is a term that seems to shed more heat than light, I mean any shop in which the worker must make his peace with a union in order to have a job. There are approximately 13½ million union members in the United States. Of these about 10 million are governed by arrangements calling for "closed" shops, union shops, maintenance of membership provisions and similar devices which make good standing in a union a condition to holding a job.

Such arrangements raise serious issues about what is commonly presumed to be the basic American right to work. Also, closed shop arrangements lie at the root of the dominant economic power now exercised by some labor leaders.

The problem of reducing the power of these labor leaders to proportions that make it safe for democracy is the age-old problem of monopoly. In an earlier era this problem was created largely by businessmen who sought to escape the restraints of competition by combinations or agreements to control prices and production. Such efforts are still attempted and must be curbed by law.

Union Labor Monopoly

But, after more than a decade during which a monopoly position for organized labor has been aggressively promoted by the federal government, the major monopolists today are those labor leaders who wield the power of enormous nationwide unions. About 90% of the soft coal miners do the bidding of John L. Lewis. A like percentage of the auto workers are represented by the United Automobile Workers of the C. I. O. About 80% of the production workers in steel are members of the United Steel Workers, C. I. O. No single corporation has more than a fraction of the economic power that is concentrated in these unions. And if corporations were to combine their power to cope effectively with that of these union monopolies they would unquestionably find themselves charged with violating the federal antitrust laws.

In its national sweep, the monopoly power of unions rests largely on their exemption from the federal antitrust laws. My previous editorial in this series (the 53rd) discussed the desirability of removing that exemption. The local roots of this monopoly power are often embedded in closed shop arrangements.

Closed Shop in Coal

An illuminating case in point is provided by the United Mine Workers, whose leader John L. Lewis has graciously given the country a 3½-month reprieve from "the hysteria and frenzy of an economic crisis," as he himself termed it. During that latest crisis the dispatches from the soft coal fields reported that the miners were standing behind John L. Lewis almost to a man. And the implication usually was that the driving forces of the strike were loyalty to Lewis and the prospect of economic gain.

Underlying that performance, however, ana basic to it was an agreement in the soft coal fields providing that "as a condition of employment all employees shall be members of the United Mine Workers." Hence to hold a job in 90% of the soft coal industry which is governed by contracts with the United Mine Workers, a miner must not offend the union. To avoid offense the union member must even be careful in criticising what his union

does. *Suspension from the union for six months, and hence from the right to hold a job,* is the penalty imposed by the United Mine Workers constitution for circulating a statement "wrongfully condemning any decision rendered by any officer of the organization."

The willingness of the miners to follow Lewis until the country froze over was not, of course, exclusively a product of the agreement limiting jobs in the coal fields to union members of good standing. Some of it originated in bad handling of employee relations in the coal fields in years gone by. But the fact remains that Lewis' soft coal monopoly has as one of its principal foundations an agreement which gives the United Mine Workers a job-or-no-job hold on 90% of the soft coal miners.

In its extreme form, the closed shop not only makes union membership a condition of employment but narrowly limits the numbers admitted to union membership and hence to the opportunity to work. In this way it is used to enforce restriction of output and working rules which would never stand up under free competition.

Fair Dealing

The closed shop raises major issues of personal freedom and fair dealing between individuals. As matters now stand, closed shop agreements require employers to discharge workers who lose their good standing in the unions involved. At the same time they frequently impose no requirement on unions to grant membership to law abiding and technically qualified persons. Many unions with closed shop agreements refuse to grant membership on the basis of competence. Thus, qualified workers are denied a fair chance to hold a job.

In its dealings with the closed shop issue the federal government has been pushed into a self-contradictory position. The National Labor Relations Act (the Wagner Act) provides, and properly, that "employees shall have the right . . . to bargain collectively through representatives of their own choosing." In furtherance of that basic proposition, the Wagner Act also provides that "It shall be an unfair labor practice for an employer . . . by discrimination in regard to hire or tenure of employment to encourage or discourage membership in any labor organization . . ." Standing alone, the provision would clearly outlaw the closed shop.

But then, to favor the closed shop, the Wagner Act turns right around and provides that "nothing in this Act . . . shall preclude an employer from making an agreement with a labor organization . . . to require, as a condition of employment, membership therein," provided that certain conditions of representation are fulfilled. This places the National Labor Relations Board in the impossible position of trying to administer a law which simultaneously points in opposite directions.

In successfully contending that there should be no closed shop arrangements on the railroads, the late Joseph Eastman, Federal Co-ordinator of Transportation, said, "If genuine freedom of choice is to be the basis of labor relations under the Railway Labor Act, as it should be, then the yellow dog contract and his corollary, the closed shop . . . have no place in the picture." The so-called yellow dog contract, which requires a worker to agree not to join a union as a condition of employment, has long since been outlawed.

At one time the closed shop was defended as a protective device for feeble young unions struggling against predatory employers. But a mere glance over the current economic scene discloses that the time when that argument was supported by the facts is past. Now it is the labor leaders who frequently exercise decisive economic power.

At elections in November three more states, Arizona, Nebraska and South Dakota, passed constitutional amendments outlawing the closed shop. In doing so, they joined six other states, which, in one way or another, have restricted the closed shop. The South Dakota amendment presented the basic issue created by the closed shop in simple and direct terms when it declared that "The right of persons to work shall not be denied or abridged on account of membership or non-membership in any labor union, or labor organization."

That issue must be squarely faced by the new Congress if its first order of business, the labor crisis, is to be resolved.

James H. McGraw, Jr.

President McGraw-Hill Publishing Company, Inc.

INDUSTRY-WIDE BARGAINING...

Death Trap for Business, Suicide for Free Labor

IF CONGRESS is to succeed in its present efforts to prevent strikes in key industries from devastating the nation, it will have to put a crimp in industry-wide collective bargaining. This kind of bargaining is designed to apply agreements between employers and organized workers on wages and working conditions to an entire industry.

Further, if extension of this type of bargaining is not curbed, there is reason to believe that it will undermine the freedom of both American business enterprise and American wage earners. For, while increasing the destructive power of labor disputes, the general spread of industry-wide bargaining would so concentrate the fixing of wages—by far the largest element in the cost of production—that government regulation would be a next short step. With that step taken, freedom for business enterprise and freedom for labor would be well on the way out.

Unfortunately, industry-wide bargaining is commonly regarded as presenting a general conflict between organized labor and employers, with unions favoring it and employers opposed to it. This mistaken notion raises the heat of much of the discussion without increasing the light. The fact is there is no such general conflict. Employers and organized workers are on both sides of the argument about industry-wide collective bargaining. For example, while some union leaders are characterizing as labor baiters all those who raise the slightest question as to the desirability of industry-wide bargaining, organized workers in the air transport industry are strenuously opposing that type of bargaining; and the employers are advocating it.

Some Employers Like It

The reason there is in fact no clear cut issue between employers and unions over industry-wide bargaining is readily understandable. It presents certain advantages to both sides in the bargaining process. For example, union advocates of such bargaining generally stress the fact that industry-wide agreement on wages protects wage standards from being undercut by lower wage areas and lower wage employers. By much the same token, however, employers who like it often emphasize the fact that industry-wide bargaining may save certain well-managed and prosperous companies from being singled out for particularly heavy wage exactions. This general point has been underlined in both the full-fashioned hosiery industry and the West Coast paper and pulp industry. There, local unions, affiliated with international unions, have protested that industry-wide collective bargaining prevents them from getting from especially prosperous employers wages as high as they could get if allowed to go it alone in collective bargaining.

So long as employers remain subject to the federal antitrust laws while unions are exempted, the balance of power in industry-wide bargaining would seem to be heavily weighted on the side of the unions. If, for example, employers were to announce an intention to match an industry-wide wage increase by an industry-wide price increase, there is no doubt that they would promptly be indicted for violation of the federal antitrust laws. Even so, the fact remains that some employers favor industry-wide bargaining while some segments of organized labor are against it.

A Clear Cut Public Issue

The industry-wide bargaining issue as it affects the public, however, is clear cut. It is concentration of economic power (in the hands of both unions and management) which can make industrial conflict devastating to the public welfare. At least five times within about a year—in steel, on the railroads, in the maritime industry and twice in the soft coal industry—strikes prompted by union efforts to impose industry-wide agreement about wages and working conditions have paralyzed large parts of the nation's economic life.

In soft coal about 90% of the production workers are members of the United Mine Workers. In steel

about 80% of the production workers are members of the United Steelworkers, C. I. O. In some other key industries there is a comparable degree of concentration of union control. In the face of such concentration many employers see no alternative but to get together on their side for industry-wide bargaining. But when they do so in key industries, the odds are lengthened that failure to agree on wages and related matters, will result in generally ruinous conflict. If agreement is reached, the chances are increased that it will take too little account of the welfare of the consuming public.

It is possible to have industry-wide bargaining on many subjects other than wages. *But the main interest is wages; and the main drive is toward industry-wide and ultimately nation-wide uniformity. Such uniformity is the deadly enemy of industrial decentralization and the pioneering expansion of industry in new areas.* Why pioneer, with inexperienced workers, if the wage rate must be uniform for the whole industry? Moreover, it would also be hard to conceive of a more effective way to put a blight on local efforts to improve industrial relations than to make wage rates and other working conditions uniform throughout the industry and then the nation. *However, among many other dangers, the overshadowing danger in industry-wide bargaining lies in its concentration of economic power.*

Wages Monopolized

On the average, the cost of labor accounts for about two-thirds of the total cost of all industrial products. The universal spread of industry-wide bargaining would thus concentrate in relatively few hands control of the greater part of the cost of industrial production. There is no reason to believe that even without disastrous strikes, such concentration would long continue free from government regulation. That would turn more earth for the graves of American business enterprise and American working men's freedom.

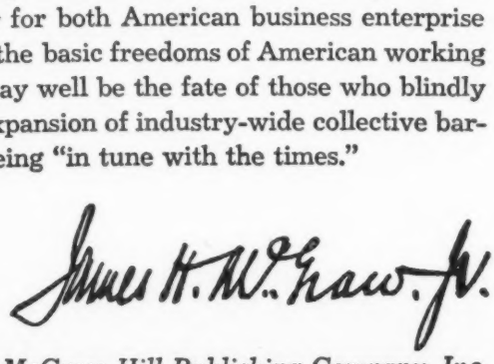
Those who believe that industry-wide bargaining serves the public well—and many sincere people do—stress the fact that, on the whole, it has worked in the industries where it has been tried over a considerable period. Most of the industries of which this is true, however, are not key industries. The pottery industry, the glassware industry, and the silk and rayon dyeing industry—to cite a few in which industry-wide bargaining has been practiced with considerable success—are important industries. But they are not industries in which strikes would have a ruinous impact on the nation. In contrast, a strike in the soft coal industry as the result of a breakdown of industry-wide negotiations quickly becomes a national disaster. The dangers inherent in industry-wide bargaining are multiplied accordingly.

England No Guide

Those who think extension of industry-wide bargaining would be good for the public often emphasize the fact that it has worked smoothly in England, where it has been extensively practiced. *Not the least of the things it has smoothed in England, however, is the transfer from private enterprise to state socialism of industries in which industry-wide bargaining by monopolistic unions and employer groups had so badly undercut competition that private enterprise had lost much of its justification.* A general extension of industry-wide bargaining could be expected to have the same consequences in this country.

The best way to curb industry-wide bargaining is a question which lies beyond this discussion. *Much would be accomplished if the federal government would discontinue its active promotion of industry-wide adjustments, in the fields of both labor and management, at which it has been busy ever since N. R. A. days. Still more would be accomplished if the federal antitrust laws were applied with even-handed justice both to unions and employers—a course urged in the 53rd editorial in this series.* Perhaps a definite limitation of the scope of labor agreements would also be necessary.

The effects of industry-wide bargaining in increasing the extent of public regulation of industry will vary. They will, of course, be less pronounced in railroads and other public utilities, which are already extensively regulated, than they will be elsewhere. For unregulated industries, however, industry-wide bargaining carries the threat of extensive regulation and, along the way, of industrial conflict devastating to the public. In these excited times, to say what I have said here is to invite characterization by overheated partizans as a foe of legitimate union progress. That is perhaps not so bad, however, as to qualify as a pall bearer for both American business enterprise and some of the basic freedoms of American working men. That may well be the fate of those who blindly accept the expansion of industry-wide collective bargaining as being "in tune with the times."



President McGraw-Hill Publishing Company, Inc.

TAX REVISION...

Can Make or Break American Business

IS THE American way of life—progress by private initiative—going to get a fair chance to demonstrate its superiority over all the challenging varieties of collectivism?

That's the real question before Congress as it confronts the long labor of remodeling the federal tax structure. What Congress does about taxes will come pretty close to making or breaking the U. S. A.

Today the tax colossus that sprawls across the national economy is unguided by any central nervous system. Its crushing weight comes down first here, then there, as the giant wobbles around, unguided by any central purpose except to grab as much as it can.

The central purpose of a tax system is simple. It should raise the necessary revenue without placing unnecessary fetters on enterprise.

As recently as 1929 federal taxes took only one dollar out of every twenty of national income. A loose-jointed and inconsistent tax structure was a nuisance then. But it wasn't serious.

Today the federal tax burden is the dominant element in the nation's economy.

Even if Congress succeeds in cutting $6 billions out of President Truman's $37.5 billion budget, federal taxes still will take about one dollar out of every five of the national income. And few Congressmen are hopeful enough to think that they can get the tax load below $25 billion for any year that is in sight.

Drastic Budget Cuts Required

Indeed, to get the tax load down to $25 billion, Congress will have to stop treating expenditures, like those for military purposes and veterans, as politically sacrosanct. Congress must scrutinize *every* item in the budget. Economy must go along with tax cutting or we shall end in bankruptcy.

Suppose that expenditures are slashed to the bone. Our taxes *still* will be so heavy that the *way* they are loaded on the nation's back will make a big difference in how well the nation gets along. That's something which the postwar boom has tended to obscure. It will become much clearer as this boom wears off. Then a remodeling of the federal tax system to remove its manifold obstructions to private enterprise will be of transcendent and obvious importance to everybody.

Tax Experts Agree

The remodeling will require political courage plus tax wisdom. Congress must supply its own political courage. But it can lean on tax experts for tax wisdom. Fortunately, tax experts now agree on the necessary reforms—especially on those that will remove obstructions to business. How well the tax experts agree is shown in the charts on the next page, summarizing answers to a questionnaire on possible federal tax reforms. The questions were asked by the Department of Economics of the McGraw-Hill Publishing Company. The answers came from a broad cross-section of tax experts, including the authors of a considerable crop of books on postwar federal taxes and what to do about them.

The experts agree (see the charts) that double taxation of corporate dividends should stop.

They agree that the tax rate on corporate income (now 38 percent) should be reduced as rapidly as possible to the initial rate on individual income (now 20 percent).

And they agree overwhelmingly that it is desirable to let net losses be subtracted from net profits over a 5-to-6-year period in computing business income for tax purposes.

All three changes would stimulate corporate initiative and hence make jobs. Averaging business incomes would make new ventures attractive even though these ventures *might* result in early losses. Reduction of the corporate income tax would have the same effect. So, too, would the elimination of that highly discriminatory provision whereby corporate dividends are taxed first as corporate profits, and again when received as income by individuals.

Penalties on Incentives

Beyond these changes, there must be an end to tax penalties on *individual* initiative. Consider the enterprising business man whose income fluctuates markedly from year to year. Because of his enterprise he may pay, on the same income, twice as much federal income tax as the man who plays it safe for a steady income. That's because he can't average his personal income over several years for tax purposes. He can count on heavy taxation of his good-year profits with no chance for offsetting against them his bad-year losses. It is a case of heads you lose, tails the tax collector wins. Eighty-six percent of the experts agree that an income-averaging allowance for individuals is desirable.

Three-quarters of them also agree that tax rates at the top end of the individual income scale (now running up almost to 90 percent) should come down. In my judgment, the total tax should not amount to more than 50 percent to encourage business men to venture for high stakes.

Advocating tax relief for men in the higher income brackets—and particularly for management men—has been considered political suicide for more than a decade. Some members of Congress still hold that view. A Democratic Congressman from Michigan told an Illinois colleague who advocated cutting upper bracket taxes, "If you put that idea forward at home, you won't come back."

The Congressman has an even better chance of not going back if our economy bogs down. One of the best ways to bog it down is to keep the taxes that destroy business incentives and block enterprise—for example, the confiscatory rates which drive the people in the high brackets away from risk-taking.

To give the American system of individual enterprise a fair chance was clearly the mandate of November's election. To give it that chance, enterprising business men must have a chance to make large rewards—as well as the always-present chance to lose their shirts. Under present tax rates, they don't get a break.

Prevailing federal taxation throttles bold business enterprise in other ways. It fails, for example, to encourage research and rapid industrial modernization. It tends to siphon investment away from private enterprise, driving it into tax exempt state and local securities. (The experts agree almost to a man that such tax exemption must be eliminated.) The list of obstacles could be amplified.

Hit-and-Run Revision Disastrous

Most of the reforms needed to prevent the federal tax system from smothering enterprise would lower federal revenues, at least temporarily. Elimination of the double taxation of corporate dividends might lop off $800 million. Dropping the corporate income tax from 38 percent to 20 percent might cut away as much as $4 billion.

Because we can not avoid enormous federal expenses in the years immediately ahead, all badly needed reforms of the type to which this article is confined obviously can't be made at once. Also there are other tax reforms bearing on consumption which obviously should be weighted in an over-all program of tax revision.

But this is equally obvious: We should have a general design for tax revision which would line up all the necessary steps. Then we could get ahead with tax reductions as rapidly—and as sensibly—as revenue requirements and political courage would permit. Tax cutting may come piece-meal, but tax planning must not.

Through such a design we might discover that some decidedly beneficial improvements in the federal tax structure can be made at relatively slight cost. But today there's no way to be sure. No one in Washington with access to the information has even undertaken to make the necessary estimate.

Instead, federal tax revision continues to be a hit-and-run business—and a short-run political business. Take, for example, the proposal of a 20 percent tax reduction across the boards. There are virtues in such a proposal. But how they stack up beside many other extremely urgent needs for tax reform remains a mystery.

Congress must dispel such mysteries. Only in that way will it do the job of converting our present jerry-built tax structure into a moderately safe abode for the American system of private initiative, sparked by adequate incentives.

EXPERT OPINION ABOUT TAX REVISION

TAX EXPERTS THINK WE SHOULD:	% Of Tax Experts Favoring the Proposed Changes
1 ***Eliminate double taxation of corporation dividends*** which are now taxed as corporate profit and then again as individual income.	92%
2 ***Reduce corporation income tax rate (now 38%)*** as rapidly as budget needs permit until it equals the initial rate for individual incomes (now 20%).	73%
3 ***Provide for averaging business' taxable incomes*** over a period of about 6 years to allow for losses in bad years.	97%
4 ***Provide for averaging individuals' taxable incomes*** over a period of a few years so as to treat fairly those whose incomes fluctuate.	86%
5 ***Reduce upper bracket individual income tax rates*** to a maximum of 50% in the $100,000 bracket and 75% in the million and over bracket.	76%
6 ***Treat capital gains, now taxed at a lower rate,*** like other income but provide full allowances for losses.	64%
7 ***Remove the privilege of tax exemption*** from all future issues of state and local government bonds.	92%

James H. McGraw, Jr.

President McGraw-Hill Publishing Company, Inc.

THIS IS THE 56TH OF A SERIES

OUR TEACHERS—

They Need The Help Of Business Now

THIS is an appeal to raise school teachers salaries—fast. Such appeals are commonly addressed, rather vaguely, to the conscience of the community. This one is not. It is addressed directly to the business community, and to its hard core of common sense.

As a whole, the school teachers of the nation are taking an economic beating. So, too, are their close associates and co-workers, the librarians. In purchasing power, public school teachers salaries, after taxes, average about 20 percent less than they did eight years ago. Beginning salaries of librarians, always low, have fallen behind an equal amount in purchasing power. College and university teachers are not much better off. The pressure is particularly heavy on those in the lower ranks. As a group, teachers and librarians are close to the bottom of the economic heap.

Unless this situation is remedied promptly, it is confidently to be expected that:

1. The more competent teachers will continue to desert our schools in droves, and our libraries will remain inadequately staffed. More than 350,000 teachers — many of them the very able ones—have left the public school teaching staff of about 900,000 in the last six years. More than 100,000 of the replacements are "substandard." They cannot meet the minimum educational requirements of their jobs which, by admission of the profession itself, are none too high.

2. Those who remain will be organized increasingly into economic pressure groups. Teachers strikes and the rapid growth of unionism among teachers at present clearly indicate what is in store.

Many business men are so deeply disturbed by the resort to the strike weapon by some teachers to enforce their salary demands that their sympathy for the general plight of our teachers tends to be dulled. Such an attitude is understandable. It avails nothing, however, in eliminating the crisis in education caused largely by teachers salary troubles.

The crisis in education is a crisis for the nation as a whole. The work of our schools, colleges and libraries is such that its deterioration means deterioration of the nation. However, the salary crisis in education is in special measure a crisis for the business community. That community has a special stake in having a well-educated and well-disposed constituency.

Education and Unionism

There may be room for disagreement as to whether teachers should organize themselves in trade unions, and follow trade union tactics. However, there is no conceivable room for disagreement as to whether organization of teachers into a fighting economic pressure group under the lash of a teachers salary crisis would be a body blow to business. Among many teachers it would foster an abiding hostility to the institution of business which, occupying a key position in the life of the community, had not done its utmost to make such unionization unnecessary by taking a lead in relieving the teachers salary crisis.

In our work of publishing technical periodicals and text books, we at McGraw-Hill meet and come to know many teachers and librarians. We know that, as a group, they have little appetite for participation in militant economic pressure groups. They are far more interested in making a militant assault on ignorance and prejudice through concentration on their professional work. If, through neglect of their economic needs by the business community, they feel forced to resort to trade union organization and tactics, the teachers and librarians can be expected to have an abiding re-

sentment toward the institution of business. That resentment will, in turn, be communicated in no small measure to the coming generation. Such is the nature of the educational process.

The crisis in education is not, of course, exclusively a matter of salaries. Unsatisfactory working conditions also play a part. Many schools are dilapidated and terribly overcrowded. So are some libraries. Some small-town school boards oppressively insist that the school teachers be the paragons of piety the board members wish they were themselves. Protection of a proper degree of academic freedom is sometimes missing. The teacher is rarely accorded a prestige comparable to the importance of the job. Elements such as these aggravate the crisis in education. But the first and absolutely essential step toward surmounting the crisis is to provide tolerable salaries.

Because of the enormous diversity of local conditions affecting teachers and librarians salaries, no general rule for emergency action would fit all cases. From state to state, average yearly expenditures on education in 1940 varied all the way from about $30 per pupil to about $150. Some states, like Nebraska, finance their schools almost exclusively from local taxes. Others, like Delaware, rely almost entirely on state taxes. Some states and communities have already acted to meet the salary crisis. Others have not. Variations such as these limit any generalization.

Guide for Emergency Action

But as a general proposition it can be safely said that the minimum requirements of the emergency will not have been met so long as the salaries of class room teachers and junior members of college faculties and library staffs have not been increased by the amount necessary to keep them abreast of the increase of about 50 percent in the cost of living since 1939. In many cases, a temporary cost of living adjustment might prove the best way to handle the problem.

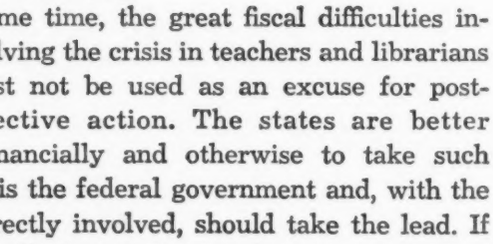
This suggestion, let it be repeated, is not offered as a solution of the salary problem, but as a start. With their salaries increased enough to meet the increased cost of living, the teaching and library groups as a whole would still have cause to envy the current economic position of industrial workers. Since 1939, the average of weekly earnings of industrial workers after taxes, has outstripped the rise in the cost of living by about 21 percent.

However, a start and an absolutely essential start would be made toward giving America the sort of educational system it must have not only to fulfill its ideals but holds its own in this highly competitive world. We worry, and I think rightly, about having the free world engulfed by Russian Communism. According to the best figures available, the U.S.S.R. is spending about twice as large a share of its total national income for education as we are. The figures compared include our expenditures for both public and private education. That comparison is really something to worry about.

States Should Take Lead

In dealing with the salary crisis it is up to the teachers to display a maturity and integrity worthy of their profession. Teachers have many employment advantages, such as long vacations. They should not slur them over in making comparisons of their annual incomes. Also employment in teaching and libraries has been notably stable. Teachers and librarians should not ignore that fact in comparing their position with those whose employment has been far less steady.

At the same time, the great fiscal difficulties involved in solving the crisis in teachers and librarians salaries must not be used as an excuse for postponing effective action. The states are better equipped financially and otherwise to take such action than is the federal government and, with the localities directly involved, should take the lead. If the price of effective action is a heavier tax burden for communities already too heavily burdened that price must be paid. The crisis presents a major emergency. To handle it as anything less is to court irreparable damage to the nation as a whole, and a special measure of damage to business as well. The intelligent self-interest of business requires that it leave nothing undone to meet and master the crisis in education.



President McGraw-Hill Publishing Company, Inc.

YOUR CHANCES OF GETTING AHEAD

FOR 20 years we have been whittling away the foundations of our economic structure. We have been cutting away the incentives to "get ahead in the world," to increase production and to improve efficiency. Unless this process is reversed soon, we risk the sort of industrial stagnation that currently afflicts Great Britain so disastrously.

How far the whittling has gone is shown by the statement in the center of the page. It shows that everyone's stake in working harder and getting ahead has been reduced sharply since 1929. In that year, anyone who was even moderately successful could look forward to reaping the rewards of his success. If he earned $5,300 annually over a period of 25 years he could retire on a comfortable income of $3,000 per year. Or he could pile up enough capital to go into business for himself. He could fulfill the American dream as phrased by Abraham Lincoln in his first annual message to Congress in 1861:

"The prudent, penniless beginner in the world, labors for wages awhile, saves a surplus with which to buy tools or land for himself, then labors on his own account another while, and at length hires another new beginner to help him. This is the just and generous and prosperous system, which opens the way to all, gives hope to all, and consequent energy and progress, and improvement of condition to all."

Look at the situation today. To retire on an annual income from investment that will buy as much as $3,000 did in 1929, a young man needs to earn over $13,000 a year for 25 years. That's more than 2½ times the income he would have needed in 1929. The same thing is true of acquiring a stake in a business.

YOUR CHANCES OF GETTING AHEAD

To see how your chances of getting on in the world have changed during the past few decades, the McGraw-Hill Department of Economics has calculated how much it now takes to save enough to acquire a retirement income or a comparable stake in a business, as compared to what it took in 1914 and 1929.

The objective set is an income from investment equal to $3,000 a year in 1929 dollars. It is assumed that the savings required to yield this income are made over a period of twenty-five years. During that period it is also assumed that $4,000 per year (in 1929 dollars) is spent on living expenses.*

Here is how the figures work out:

	Yearly Income Needed
1914	$3,075
1929	5,267
1947	13,221

It now takes more than four times as large an annual income as it did in 1914 to gain a comparable stake. It takes well over twice as much as it did in 1929.

Changes in three factors — federal income taxes, living costs, and interest rates — explain why the income needed has multiplied so. Here's how these factors line up for the three years.

	Federal Income Taxes Married Man, 2 dependents		Cost of Living (Index Numbers 1935-39)	Interest Rate High-grade Corporate Bonds
	$5,000 income	$10,000 income		
1914	$10	$60	71.8	5%
1929	$3	$40	122.5	5%
1947	$589	$1,862	155.0	2½%

Similar calculations show that if we could reduce federal expenditures from $35 billion to $25 billion annually, raise interest rates by one-tenth and lower living costs by 15% — all realistic possibilities if we make the effort — then the income needed to build up such a retirement fund would come down to $9,500. The chances of realizing that goal would then be restored to what they were in 1929.

*Several other factors were omitted from the calculations because they would not have a decisive effect on the results. Thus, existence of social security pensions and retirement funds now reduces the income needed; but if state income taxes were added, the income needed would increase.

Why Try to Succeed?

While the income needed for retirement today has increased 2½ times — or by more than 150% — since 1929, the average person's income has increased only 80%. So the average man's chances of achieving success are really slimmer now than a generation ago.

This 1929-47 trend is something new in America. The average person's chances of getting ahead improved during 1914-29. In that period the dollar income needed for retirement or a stake in business rose by 75%, but the average income rose by 100%. So more people were within striking distance of success and security in 1929 than in 1914. The story has been different since 1929.

Fewer people actually do achieve financial success today. Only 1% of all families now have incomes large enough to build up a retirement fund or a stake in business. In 1929 almost 6% of all families attained a comparable degree of success.

Higher taxes are the most important reason why it takes so much more now to build up a competence. They account for one-half the increase in the amount needed. The other half is explained by higher living costs and lower interest rates.

It is, of course, true that few people ever get into the higher income brackets. So the process of cutting

away the incentives which play such a key role in our economic system affects comparatively few people immediately. It does, however, have a powerful indirect effect on all of us.

Everybody Loses

When half to four-fifths of any additional income of successful people goes to Uncle Sam a heavy drag is obviously put on doing the work to get it. Thus, we stand to lose the benefit of full use of the nation's best brains. By so doing we stifle industrial progress. And the loss in productive efficiency far outweighs the tax revenue the Treasury gains. Carried far enough, the process of stifling economic progress by slashing rewards leads straight to industrial stagnation.

The same process also multiplies the risks of embarking on new capital investment. High taxes rule out all but the most profitable new projects and restrict most expansions to boom times when profits are high. So capital investment follows a boom and bust pattern and, by so doing, contributes much to ups and downs in production and employment.

The Sorry Plight of Britain

The case of Britain today provides an object lesson of how blighted incentives produce industrial stagnation. *Britain's number one economic problem is to get more production. But the tax load there is so heavy it stifles the incentive to produce more.*

A coal miner who works an extra shift pays about a third of his added earnings to the tax collector. And, as the London *Economist* comments, tax rates on business executives are so high that they kill every incentive except that to tax evasion. In short, not only is the incentive to succeed blighted, but so is the incentive to work.

A root-cause of Britain's trouble is this: The cost of an expensive program of social benefits has been piled on top of the heavy costs of paying for past wars and trying to prevent future wars. Tax rates are boosted accordingly. What her experience proves is that the attempt to provide excessive social benefits may defeat itself. It raises the tax burden on rich and poor alike and smothers the incentive to work. So the underlying basis of all economic benefits—production—is eaten away.

We in the U. S. haven't traveled as far down the stagnation road as Britain has. Taxes amount to about 26% of national income here as against about 45% there. But, unless we start soon to build up incentives to do better work, instead of whittling them away as we have been doing, we will catch up with Britain fast.

It's Late but Not Too Late

Can anything be done? Decidedly yes, *particularly by tax reform and reduction in the cost of living.* As far as interest rates are concerned, any large increase would raise excessively the cost of carrying our war-swollen national debt, and hence raise taxes. But some increase in what are now excessively low interest rates may well be both feasible and desirable.

Action on the tax front is the first order of business. Our jerry-built tax structure is the thing that is chiefly responsible for cutting the incentives to work harder. Two things are important: 1) Government spending must be pared to the bone; 2) The tax system must be completely overhauled to remove the shackles on all-out production.

The 56th editorial in this series, published in March, outlined major steps that need to be taken in remodeling federal taxes in order to increase incentives to individual and business enterprise. *The revenue bill now before Congress is no more than a short step in the right direction. Much more must be done to clear the way for high production and rising living standards.*

Lifting the blight which taxes now place on incentives would help cut the high cost of living. It would stimulate greater production and greater efficiency. But a further step is necessary. Part of the benefits of improved efficiency must be passed on to consumers in the form of lower prices.

In the past few years we have been following precisely the opposite course. In many cases wages have been increased all out of proportion to increased productivity. Result—soaring prices and a severe squeeze of the consumer, to which some greedy exploitation of war-created shortages has also contributed.

To Give Ability a Chance

Our basic and most crucial problem is to get back on the track which leads to higher production and improved living standards all along the line. We got off that track in the 30's. Then, we started scrambling for larger slices of the same pie instead of trying to produce a larger pie. Now the process of getting back on the track is greatly complicated by the tremendous tax burden growing out of the war.

Yet it's not too late to turn back from the road that leads to industrial stagnation. As the statement in the center of the page shows, we could restore the odds of getting ahead to what they were in 1929. Cutting the federal budget to $25 billion a year and putting the tax structure in good order are the crucial first steps.

By taking these steps soon, Congress can go far to restore the incentives to hard work and efficiency which have been so largely washed away in the past 20 years. If they are not taken the American dream of getting ahead by hard and effective work will exist only in the history books, and our children will inherit from us an economic order without opportunity, without hope, without individual liberty.

President McGraw-Hill Publishing Company, Inc.

THIS IS THE 59TH OF A SERIES

THE RUHR—
VALLEY OF DECISION

FOR AMERICANS and for American business the most important single spot on earth today is the Ruhr Valley of Germany—a valley no bigger in area than the State of Rhode Island. Upon recovery in the Ruhr hinges recovery in Europe. Upon recovery in Europe hinges the peace of the world.

No machine can run with its most important part missing. Western Europe without the Ruhr is a dead machine. Before the war, over half the coal and steel produced in the Western part of Continental Europe came from this one little valley. Today, the fact is that no other region in Europe has the technical skills and enterprise to produce the industrial supplies which Europe must have if it is to help itself back to a self-supporting economy. And, after observing Europe for many weeks, I am convinced that no one but the United States can successfully supervise the rebuilding of the Ruhr.

If you will keep four considerations in mind, as the international politicians gamble, you can easily tell whether the United States is playing its proper role in the rehabilitation of the Ruhr. Here are the four considerations:

I. We are paying for the Ruhr rehabilitation (or the lack of it).

II. We alone have the skill and enterprise to supervise its rebuilding.

III. It will be a tough organizing job requiring money, hard work, and outright sacrifice on the part of management men and technicians.

IV. We had better do it well if we love our children.

I

We are paying for rebuilding the Ruhr—or we soon shall be. The British now control the Ruhr, its government and its industry. They have been paying out about four hundred million dollars—American dollars—a year to buy the food, raw materials and equipment needed to rebuild the Ruhr. The British must spend American dollars for these supplies because the supplies can not be bought anywhere but in America. Thus far the British have, in effect, obtained the dollars which they spend for the Ruhr by drawing them out of the $3,750,000,000 loan which we granted Britain last year.

Now the loan is fast running out. The British lack dollars and other assets. We must take over, directly or indirectly, the dollar expenditures for rebuilding the Ruhr. We shall pay for it. Therefore—

II

We should supervise it. The British have been running the Ruhr's industry. They might conceivably suggest to Washington that they continue to run it while we pay the bill. *That we should never agree to.* There is a sound old rule that he who pays the piper shall call the tune.

Perhaps we would not need to invoke that rule if the British had done a good job reviving the industries of the Ruhr. *They have done a poor job—physically and ideologically.*

The physical output of the coal mines and steel mills of the Ruhr in recent months was actually smaller than at the first of the year. Production of coal amounts to little more than half of the pre-war 127 million tons per year. Steel productions limps along at one-sixth of the pre-war rate—far below the volume permitted even under the present low level-of-industry plan for Germany.

Ideologically, the British Labor Government has tried to export to Germany the brand of socialism which is making such a dubious record at home. Foreign Minister Bevin—although he may now have misgivings about it—committed himself to nationalization of the Ruhr's coal and steel industries. British representatives have pushed hard to get General Lucius Clay, our able military governor in Berlin, to agree to socialization of the Ruhr. So far, he has resisted this pressure, but our State and War Departments and we as individuals must back him up to the limit if he is to continue to combat this pressure successfully.

Even if the British government were not socialist, there would be good reason for questioning the ability of Britain to rehabilitate the industries of the Ruhr. In recent generations, the British management class has shown itself more

interested in cartels, restricting output, and allocating markets, than in full-steam, ingenious enterprising production.

Certainly the British must remain full partners in the *political* administration of Germany. No one suggests anything else. However, their recent production record demands turning the job of revitalizing the Ruhr industries over to the nation which is paying the bill and which leads the world in production.

If we have any faith in the business philosophy by which we have lived and prospered for 170 years, we should demonstrate that that philosophy still is dynamic by taking up the burden of the Ruhr.

III

It will be a tough job. It will require men and supplies and money from the United States. It can not possibly be done in less than five years. A list of some of the necessary steps shows how hard it will be.

A. Plans for socializing the Ruhr should be shelved quickly. The industries there should remain in trusteeship for five years. Then the Germans themselves should decide their ownership; let us hope that by that time we can demonstrate to them that private ownership and private initiative mean high production, good distribution and high wages.

B. The top supervising management jobs—both the top policy and the top technical jobs—required outstanding business ability. That is why American business men must be willing to go to Germany, sacrificing comfort and leisure, and even income, if necessary.

C. Germans should take over the management job at the operating level. The Germans are good technicians. They have a greater incentive than anyone else for getting the Ruhr back in working order. That incentive should be harnessed.

D. Special effort should earn special rewards. There is nothing wrong with the Ruhr (or the rest of Europe) that hard work will not cure. Before a man will work hard, he must feel that his work will advance him and his family. That simple motive, which powers our whole economy, must be revived in the Ruhr. To revive it requires enormous ingenuity and work... a new currency... a logical customs union... a sensible ration system... enough food, clothing, housing and consumer goods so that the worker can buy something with his currency and his ration points.

E. America will have to furnish a good share of these foodstuffs and supplies. Certain key items of equipment also will be needed. Only as we succeed in our job can this flow be diminished.

F. A sensible priorities system must channel Ruhr coal and steel into those uses which, in turn, will further increase output. Repair parts for railroad cars should stand high on the list. Housing, coal equipment and machine tool parts should come ahead of the automobiles and permanent steel bridges which at times have been accorded preference.

German technical management of industry in the Ruhr—point C above—need not mean *political* control of the Ruhr by some future sovereign German state. As the French know, the Ruhr, next to the atomic bomb, is the most dangerous weapon in the world. It is the arsenal without which no European power, even Russia, would dare start a war. There is no sense in turning that arsenal back to the *political* control of a nation which twice in 25 years used it for aggression. (And three times since 1870.) Surely we have enough resourcefulness to let the Germans who live in the Ruhr run the industries there without turning political control over to a central Prussian state.

This partial list shows how much hard work and statesmanship the United States must put into the Ruhr. But—

IV

We had better do it if we love our children. If we do not do this job—if we should pull out of Germany or fail there—we leave behind us a vacuum which neither Britain or France has the strength or ability to fill. Russia has the will and, if left unopposed, the power to fill that vacuum. Therefore, the day we fail or the day we pull out of Germany, the third world war takes a long step closer to us and certainly to our children. What greater incentive does any American need to work for than our success in this field?

If we succeed, the western zones of Germany in conjunction with Belgium and Holland can become self-supporting in three to five years. That way lies recovery for all Europe. That way lies peace for the world. That way lies vindication for the American business system in which we believe—the system of competitive private enterprise, with freedom for the individual and his initiative.

President McGraw-Hill Publishing Company, Inc.

WHILE WE DELAY—

Russia Drives for the Atlantic

IN THE STRUGGLE to keep western Europe west of the Iron Curtain it is later than you think. Unless the United States quickly mobilizes its own and other nations' resources, World War II will be lost as World War I was lost—by no economic follow-through.

Millions of people in western Europe, living in cold homes or no homes at all, face another winter of near starvation. Some countries are absolutely without dollars to buy abroad the food and fuel they need for survival. Others slide toward that desperate state.

In this welter of misery Russia grasps for dominion over all Europe. Everywhere, as cold and hunger deepen and as men begin to doubt America's determination to help, Russia turns on the pressure. In France the Communists drive to overthrow the Government. In Italy they do likewise. In Greece Russia kills the United Nations investigating commission. In Trieste Tito elbows us out of the way. In Germany and Austria the Soviet commanders alternately stymie and flout the Allied governments.

FACED WITH this bloodless attack, the leaders of western Europe and of the United States have not covered themselves with glory.

Look, for example, at what the sixteen European countries participating in the Paris meetings on the Marshall "plan" first proposed to the United States as a catalog of their needs. In the main it was simply an adding up—to $30 billion—of what the various countries thought they needed to keep going in the same old way at the same old stands. There was no real start on plans for the mutual aid by European states which is the essence of a successful recovery program . . . no real start on plans to knock down the barriers which divide European trade into hopelessly inadequate little pockets . . . no real plans to clean up currencies which deteriorate so fast nobody wants to work for them. *In fact no plans to make people want to work.*

Meanwhile, what have our leaders offered? Not much more than one fine commencement speech by General Marshall, outlining a good idea, and a couple of carloads of statistics, with more to come.

Not even a beginning has been made on the most crucial part of any European aid program—*that of explaining to the American people what their part must be and why.* It is true that not all the reports of all the statistical committees have been completed. They never will be. But it is also true that the broad outlines of what the United States must do to save Europe are already clear. And it is not simply to provide more dollars, although $12 to $16 billion more—the cost of 6 or 8 weeks fighting in World War II—may be required.

A far more basic requirement is leadership which will lift Europe out of the slough of despair and get recovery rolling. Without that leadership more billions for Europe will buy us nothing but more bitterness and remorse on both sides of the Atlantic.

WHAT ARE the ingredients of that leadership? Here are a few:

1. A bi-partisan program for European recovery.

It should be so thoroughly understood and so overwhelmingly supported by both parties that playing politics with it will be like selling military secrets to the enemy.

Truman and Vandenberg have failed miserably to develop and explain a complete program—one in which Europe and America can have full confidence. Nor have Taft and Dewey and other candidates for high office pledged that politics will stop at our shoreline. These men must speak out. To date Herbert Hoover alone has had the courage and vision to state a program.

2. A mobilization of American food supplies.

We must assure people at home and abroad that our crops, cut down by drought and heat, will be stretched to cover minimum European needs (with whatever help we can muster from other nations) without forcing still higher food prices here.

Some food experts are comfortably confident that the stretching can be done. But

meatless and wheatless days, higher extraction of flour from wheat and similar voluntary conservation moves would make it surer. And they would demonstrate that a free country can mobilize itself to meet a very serious crisis.

3. An understanding that relief is one problem and recovery another.

Both problems must be solved. Relief emergencies must be met, some of them at once. But they must not black out the longer task of recovery. Italy illustrates the point. Italy, particularly the south, is flat broke. Help is needed right now to keep people from dying in the streets. But we must eventually do more than keep the Italian people alive. We must help them get back to useful work so that they can stand on their own feet.

4. A steady insistence on results—which means that Europe must find a way to make its people want to work.

In the U.S.S.R. they have a way to get things done. It is to liquidate those who do not work. In the U.S.A. we have a way to get things done. It is to create incentives to make people want to work. Western Europe, notably France and Britain, has fallen between two stools. It has socialized away the incentives, and it does not yet, thank heaven, enslave the laggards. We should make it crystal clear that we have no designs on the national "sovereignty" of others. But we should make it equally clear that we insist that those countries which receive our aid work hard enough to get results. To this end continued aid should be on an installment plan, each installment conditional on getting results. Otherwise more billions can easily disappear down the drain.

5. Insistence on all-out self-aid by European countries.

That is the constructive core of the Marshall idea—to help Europe to help itself. In his brilliant "Report on Germany" and how to get it "off the backs of the American taxpayer," Lewis H. Brown, Johns-Manville Chairman, shows how the export of only 10 million tons of coal a year from Britain to western Europe would speed industrial recovery of the Ruhr immeasurably. There are countless other cases where effort in one European country—or a group of countries—will break a big industrial bottleneck in another. We should insist that everything possible be done to see they are broken.

6. An agreement with Britain and France giving us authority in western Germany equal to our responsibility.

Britain is shifting to us most of the financial burden she has been carrying in the German occupation. Less directly we shall also be carrying much of the French occupation load too. We must have authority in the economic field commensurate with our responsibilities. Otherwise the management of western Germany can poison Anglo-American and Anglo-French relations in addition to wasting resources we could use to promote general European recovery.

It is truly said in the scriptures that the Lord loveth a cheerful giver. But it is not recorded anywhere that anyone, including the recipient, loves a soft-headed giver. Hence as a capstone any program of aid for Europe should have machinery assuring that only what is needed is sent; that what is sent does the job for which it is sent; and that arrangements are made for the recipients to pay back whatever they can.

THE AMERICAN PEOPLE should be told clearly by their leaders that there is no assurance that the best possible program of economic aid for Europe will do the job. The time is very late.

In France and Italy, as our help falters, the Communists right now are provoking strikes which will make the people's suffering more acute. They hope, of course, to overthrow the governments in both those countries and to seize control. If Communist dictatorships are clamped on France and Italy this fall, Russia and her satellites will have advanced to the Atlantic. The Iron Curtain will have moved 500 miles west—toward us.

Americans should be clearly told, therefore, that not to undertake an immediate program for the recovery of Europe is to bring closer the greatest possible national disaster—World War III.

President, McGraw-Hill Publishing Company, Inc.

THIS IS THE 61st OF A SERIES

TAFT-HARTLEY ACT

Frees "Slave" Labor

THE TAFT-HARTLEY ACT is two months old. Its full meaning is yet to be determined by decisions of the National Labor Relations Board and the courts. However, on its face, the Act refutes the attacks made upon it by union leaders as hysterical and fanciful.

Management has had every provocation to reply to these attacks in kind. To the credit of the employers of this country, they have not succumbed to that temptation. They have maintained a temperate attitude toward the new law and the problems it is designed to correct. This approach is right. But it is only an approach.

Union leaders will want to settle for nothing short of *repeal.* Their attack on the Act has made some headway. It may be more effective as time goes on. *Certainly the Taft-Hartley law will be repealed if management just sits tight and lets union leaders continue to confuse their followers.*

Management, therefore, must implement its present temperate attitude with a program of positive action. The Taft-Hartley Act must be made to work not because management wants it, but because it is fair to labor — and management can do things right now to see that the Act works. Management can:

I. Utilize every means at its disposal to acquaint the rank and file of union workers with the truth about the Taft-Hartley Act.

II. Suggest amendments to the Act if experience indicates that amendments are necessary.

III. Use the law as little as possible in settling labor disputes.

IV. Stand firm in its refusal to bargain away the rights accorded by the Act to workers, management, and the public.

An examination of those four *must's* will show why they provide management with its best program of action.

I.

Union members do not know what the Taft-Hartley Act provides.

There is abundant proof of that statement.

While Congress was still trying to write a law that the President would not veto, FACTORY magazine asked workers how they felt about major proposals in the pending House and Senate bills. Overwhelmingly they felt good. They were in favor of almost every individual provision that was finally incorporated into the bill and passed over the President's veto.

The same story emerged from the national opinion poll made by the Opinion Research Corporation of Princeton, N. J. and published by Look magazine after the law was enacted. It showed that union members uniformly favored major provisions of the Act, but were strongly opposed to the Act itself.

This inconsistency is easily explained. Instead of telling their members what the Act does for them, most union leaders have been condemning it as "a slave labor law" because it curtails the leaders' power and recognizes the rights of the union member and the public.

It is not a slave labor law. All of the basic rights accorded to labor by the Wagner Act of 1935 are preserved by the Taft-Hartley law. All of the unfair labor practices that were forbidden by the Wagner Act are still forbidden by the Taft-Hartley Act.

Nothing in the law impairs labor's right to bargain through representatives of its own choosing.

The Wagner Act condemned as an unfair labor practice any effort by employers to coerce employees in the selection of their bargaining representatives. So does the new law.

The Taft-Hartley Act merely recognizes rights of individual employees, of management, and of the public that were ignored by the Wagner Act.

For example, while the Taft-Hartley Act continues the workers' protection from coercion by employers, it also gives them new protection against coercion by unions. The individual worker is freed from the necessity of joining a union to *get* a job. He may still be required to join a union to *keep* his job, but not unless a majority of the workers vote for such a requirement in a government-supervised election.

Some people think the Taft-Hartley Act is weak in protecting the rights of the individual worker. They think that membership in a union should never be made a condition for holding a job. This is true. However, the Act does restore to the individual worker some rights which were blotted out under the Wagner Act, just as it does to management and the public.

A fair examination of the new law's provisions will show that they spring from one dominating purpose: i.e., to re-establish equality before the law.

For example, under the Wagner Act union leaders were free to say whatever they pleased about the employer to his employees. The employer, on the other hand, was denied freedom of speech in talking to his own employees. Now freedom of speech is largely restored.

Under the Wagner Act the employer was compelled to bargain with a certified union. Now the union must bargain, too.

Under the Wagner Act, unions alone had the right to petition for an election to determine whether the petitioning union represented a majority of the workers. Now the employer also has the right to secure an election.

These are features of the new Labor law that management must help workers understand. They must understand why the Act is not the "diabolical monstrosity" Philip Murray tells them it is.

Some companies have already started to explain these things to their workers. Techniques are well established, and they are techniques that any company can use. They include labor law digests in language workers can understand, supervisory conferences to cover points in the Act that affects the supervisor's handling of his job, distribution of reprinted articles that point out how employees benefit from the new law, editorials in plant newspapers and magazines, and advertisements in local newspapers.

II.

Management should take the lead whenever amendments to the Taft-Hartley law become necessary.

For twelve years labor leaders wilfully opposed every attempt to correct obvious abuses in the Wagner Act. We have now proved that a labor law *can* be amended. Let us be sure that management does not resort to the same obstructionist tactics labor has always used.

In carrying out its basic purpose to re-establish equality before the law, the Taft-Hartley Act makes it "unlawful . . . for any corporation whatever or any labor organization to make a contribution or expenditure in connection with" national elections. Corporations have long been so restrained. The novelty is the balancing restraint upon unions, which now have huge financial resources amounting to very many millions of dollars. However, the language of the Act *may* restrain the labor press from saying what it thinks about candidates, thus impinging upon the freedom of the press. Senator Taft has recognized this possibility.

If it should develop that the Act inadvertently throttles freedom of the press—or misfires otherwise—management should take the lead in securing suitable amendments to the Act. By assuming a completely stiff-necked attitude toward any and all changes in the Wagner Act, no matter how badly needed, the dominant labor leaders and their political outriders finally brought on the sweeping revisions provided by the Taft-Hartley Act. Management must not follow that example of stupid leadership.

III.

Management will be wise if it uses the new law gently in settling labor disputes.

So far employers show no disposition to use the law excessively. That is good. An analysis of the NLRB's docket from August 22 to September 30 shows that approximately 90 percent of the cases now before the Board were filed by unions and employees—not by employers.

We have been surveying employers, asking if they will have occasion to use their right to sue their unions. The answer so far is consistently, "*no.*" That answer frequently is accompanied by this remark, "We certainly hope not. We have no desire to conduct our labor relations in the courthouse."

The desired result should be for the Act to produce only those law suits that are matters of vital principle. As many employers have remarked, the courthouse remains the worst possible place to conduct labor relations. The best place is in the plant—by free collective bargaining between parties enjoying an equality before the law. The Taft-Hartley law will serve its most constructive role if it encourages this kind of collective bargaining.

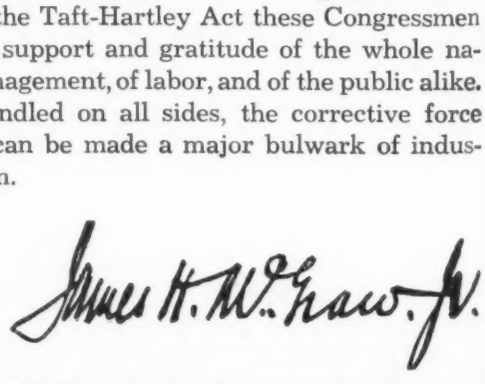
IV.

Employers should not bargain away legal rights accorded to them by the Taft-Hartley Act.

By bargaining away rights given them in that Act, employers serve only to upset a carefully created balance of equality before the law which is an essential element of fair collective bargaining.

Also, by bargaining away rights properly accorded to them, they let down those members of Congress who, in voting for the Act, braved continuous threats of political assassination by powerful union leaders. For their statesmanship in the complicated field covered by the Taft-Hartley Act these Congressmen deserve the support and gratitude of the whole nation—of management, of labor, and of the public alike.

Fairly handled on all sides, the corrective force of the Act can be made a major bulwark of industrial freedom.



President, McGraw-Hill Publishing Company, Inc.

POLITICAL ACTION—
Labor's Blind Alley

THE approach of the 1948 elections brings organized labor in America to a fork in the road.

Straight ahead lies the familiar route of free collective bargaining. Except for an occasional side trip, labor has been traveling it for years. On this road the role of government is to act as traffic cop, removing obstructions for all travelers.

The fork is the road of political action—the road to special privilege for labor. On it government is called upon to clear a special right of way for organized labor—to push aside all others.

Which of these two roads will organized labor take?

Most American labor leaders are now urging their followers toward political action. Their first objective is to "get" all members of Congress who voted for the Taft-Hartley Act. AFL plans to raise a $5 million political combat fund through contributions and a per capita tax on its membership. CIO is soliciting $1 donations for political action from its 6,000,000 members.

For their own sake, however, as well as for the welfare of the country as a whole, the rank and file of organized labor will do well to stop, look and listen before they turn their unions into political action squads. If they examine the facts for themselves, they will make two significant discoveries:

I. Political action is a blind alley for labor.
II. The Taft-Hartley Act is an essential bulwark of free collective bargaining.

A brief discussion of these two statements will show what they mean to organized labor.

I

Political action is a blind alley for labor.

If there is any doubt about that statement, a good way to dispel the doubt is to look at European countries where organized labor has been following a political action line.

Britain, where the Labor Party is in power, is such a country. How is labor faring there? Measured by the good things money buys, the average hourly wage in Britain is less than two-thirds of what it is in the United States. Part of the difference may be accounted for by the fact that the British Isles are poorer in natural resources than the United States. Another reason is the war damage to Britain's plants.

But there are two other big reasons why the British wage earner is far behind the American worker in enjoying the good things of life:

1. The *incentive to produce* has been dulled by vote-catching programs which promise economic security and a levelling of incomes. Lulled by promises of cradle-to-the-grave security and discouraged by high taxes, the British have descended to a state neatly described by the London *Economist:*

"Nobody gains anything from activity or suffers anything from inactivity."

2. To run a program like Britain's requires more and more government functionaries. Civilian employees of the British government have increased by 50% since before the war, putting one worker out of ten on the government payroll. More and more people stop producing and spend their time instead cutting up what others produce. The result is smaller production, higher taxes and lower real wages.

The British Labor Party must accept most of the responsibility for this sorry state of affairs. It is due primarily to a program of political action by organized labor which promised the individual worker security and equality of income—*but which can not deliver either because the incentive to work is gone.*

The lesson for American wage earners is clear. Political action by unions to enforce the economic fallacy of more-and-more-for-less-and-less will end by impoverishing the working man—and bringing the nation to ruin.

Unions exist for collective bargaining, not for politicking.

II

The Taft-Hartley Act is an essential bulwark of free collective bargaining.

Bargaining works satisfactorily only when both parties—management and labor—think they are getting a fairly even break.

Management was very sure that the Wagner Act, as administered from 1935 to 1947, was giving employers the short end of the stick. Furthermore, management's feeling of frustration was no whim. It was justified by case after case where rights were granted to organized labor with no counterbalancing recognition of the rights of management, of individual workers or of the public.

The Taft-Hartley Act goes a long way toward establishing equality in employer-union relations. It may fall short of doing a perfect job. *As a subsequent editorial in this series will show, it leaves virtually untouched the public menace of industry-wide bargaining and labor monopoly. And it leaves unprotected what should be the individual's right to hold a job without joining any particular organization.* But it *does* provide some major safeguards for collective bargaining by striking at abuses.

Organized labor, therefore, has no cause to damn the members of Congress who voted for the Taft-Hartley Act. True, the law will check what has been an uninterrupted march of the labor union bosses toward absolute power. It will do so just as laws in the past—The Sherman Anti-Trust Act, for example—have checked management when it was too greedy. And, as the first section of this editorial points out, the time has come to check the march of the big labor bosses.

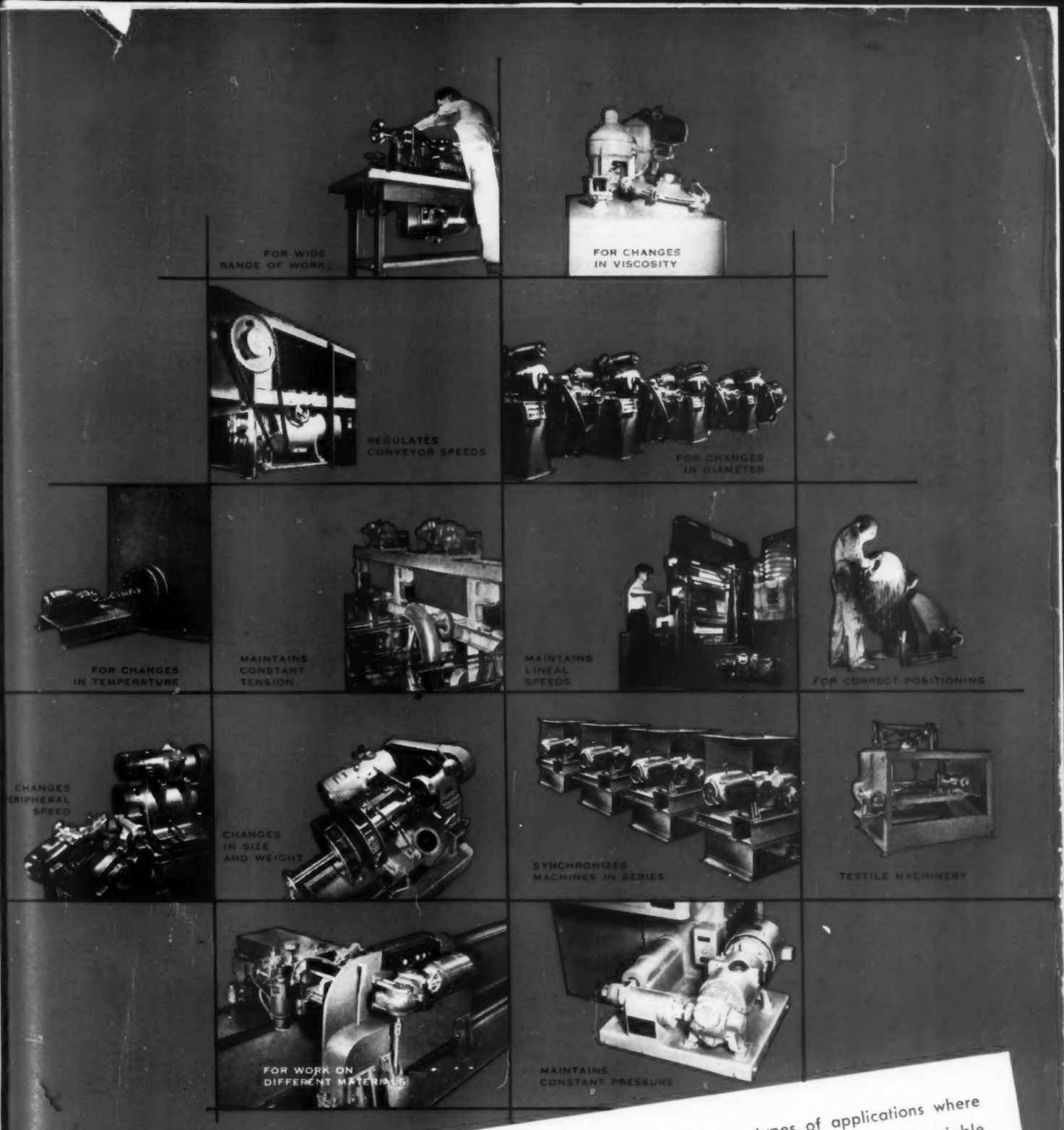
Fundamentally, the Taft-Hartley Act gives free collective bargaining a new lease on life. The old lease was running out because the Wagner Act stacked the cards against employers, against individual workers, and against the public.

The road to free collective bargaining is now clear of many of the most menacing obstructions. It is the only road for labor to take in its own self interest. Union workers who let their leaders lure them down the blind alley of political action will do so at their own peril—and at the peril of this great industrial nation.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

THIS IS THE 63RD OF A SERIES



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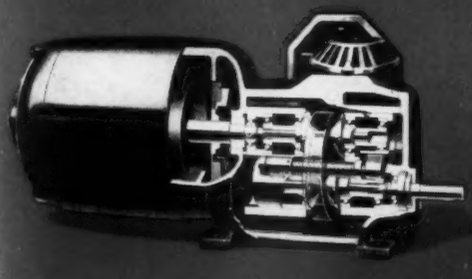

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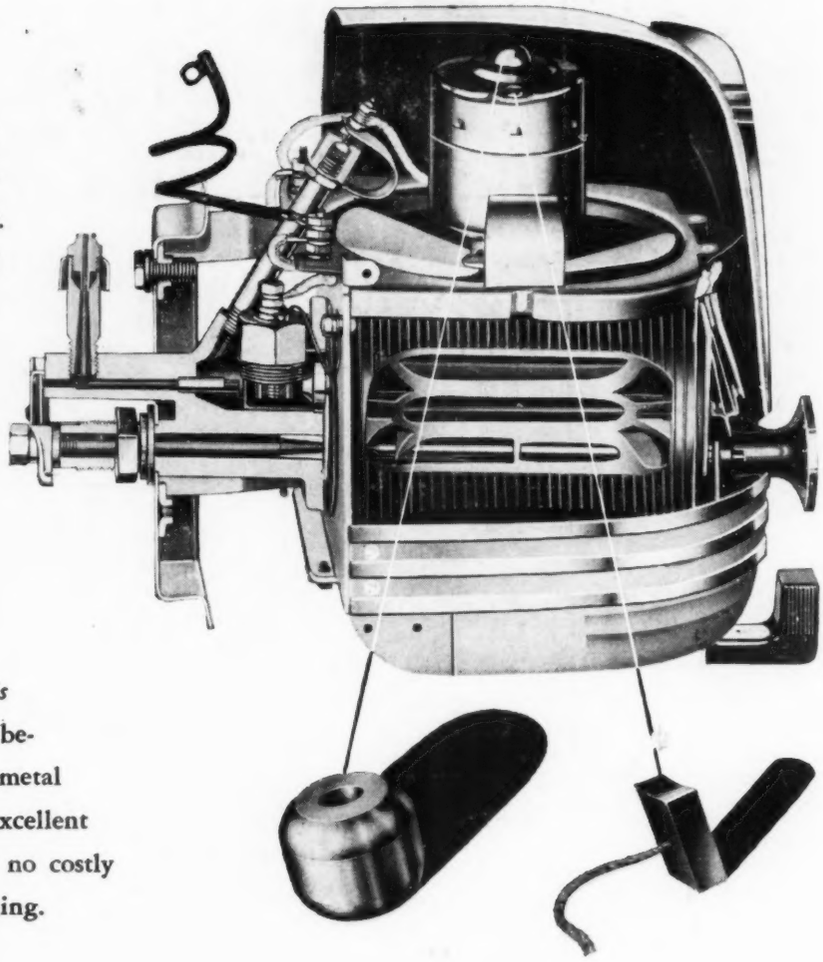

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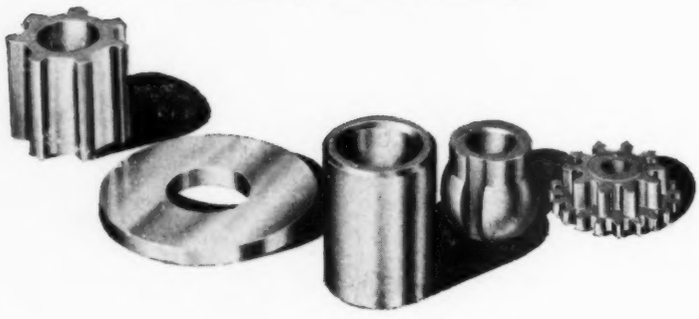

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